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State Board of Health

of the State of Ohio

Report of a Study of the Collection and Disposal of City Wastes in Ohio

1910

Supplement to the 25th Annual Report

SUPPLEMENT

TO THE

Twenty-Fifth Annual Report

OF THE

State Board of Health

OF THE

STATE OF OHIO

REPORT OF A STUDY OF THE COLLECTION AND DISPOSAL OF CITY WASTES IN OHIO.

1910

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LETTER OF TRANSMITTAL.

COLUMBUS, OHIO, July 17, 1911.

To DR. C. O. PROBST, *Secretary of State Board of Health.*

DEAR SIR:—Herewith is transmitted a report by Mr. W. H. Dittoe, assistant engineer, of a study of the collection and disposal of city wastes in Ohio.

The studies described were carried on by this department during 1909 and 1910. The procedure of the field and laboratory investigations was arranged by Mr. Paul Hansen, formerly assistant engineer and acting chief engineer of the Board; and the studies were conducted under his direction. Mr. Hansen's retirement from the employ of the Board shortly after the completion of the field and laboratory work made it impossible for him to prepare this report but we are indebted to him for many valuable suggestions which aided materially in its preparation.

No definite conclusions or recommendations are made as a result of these studies and it does not appear advisable that they be made at this time, inasmuch as the subject treated is so broad in its scope and the present knowledge of it so limited. It is intended, therefore, to simply present the facts revealed by a study conducted in as thorough a manner as time and available funds permitted; and it is believed that the data presented will be of value in future investigations of the subject.

Acknowledgement is due the local officials in the various municipalities in which the studies were conducted for their valued assistance.

Respectfully,

R. WINTHROP PRATT,
Chief Engineer.

REPORT OF A STUDY OF THE COLLECTION AND DISPOSAL OF CITY WASTES IN OHIO.

FOREWORD.

In 1907 the Ohio State Board of Health decided to conduct through its engineering department a special study of the collection and disposal of municipal wastes in several cities of Ohio. On account of unavoidable delays the work was not started until the spring of 1909. It was then carried on for one year, until June, 1910, the laboratory studies extending to November of that year. Nine cities of the state were selected for study, and in four of the largest cities, Cleveland, Cincinnati, Columbus, and Dayton, visits of one or two days' duration were made each month during the investigation. Each of the five smaller cities, Canton, Mansfield, Steubenville, and Zanesville, were visited on one or two occasions during the year. In connection with the field studies, analytical data were obtained by the examination, in a special laboratory at Columbus, of samples collected in the various cities.

In this report, it is aimed to present in concise form descriptions of the character and quantity of various city wastes, the methods of collection and disposal practiced in Ohio, and the general sanitary and economic efficiencies of the methods in use.

The studies were carried on under the supervision of Mr. Paul Hansen, assistant engineer and acting chief engineer of the Board. The men engaged in the investigations and the compilation of the data contained in this report were as follows:

Mr. W. H. Dittoe, assistant engineer; conducting field studies.

Mr. A. H. Flower, chemist; conducting laboratory studies.

Mr. R. F. MacDowell, engineering assistant; on field work after September 1, 1909.

Mr. L. H. Van Buskirk, engineering assistant.

Mr. M. Z. Bair, engineering assistant.

INTRODUCTION.

City wastes disposal is rapidly becoming one of the most important of municipal problems, and its recognized sanitary aspects are demanding attention from sanitarians in much the same manner as public water supply and sewerage improvements. It has been only in comparatively recent years that the attention of engineers and sanitarians has been directed toward the problems involved in the disposal of city wastes; and municipalities themselves until rather recently have in general neglected this important branch of the public service. The collection and disposal of municipal wastes, which were formerly considered unpleasant duties of the public official, are now demanding recognition and careful and exhaustive study. From the standpoint of the general health and welfare of a community, the problem of the disposal of waste material has an importance ranking favorably with that of its public water supply and sewerage facilities.

The development in city wastes disposal in this country is of comparatively recent growth, excepting in the large cities where rather well organized methods have been practiced for a number of years. In the past ten years the development in cities of 50,000 and upwards has been rather active, and it is quite likely that this activity will continue in the future.

Omitting sewage, the wastes of a municipality may be briefly classified as follows:

1. Garbage.
2. Rubbish.
3. Ashes.
4. Street cleanings.
5. Dead animals.
6. Manure.
7. Night soil.
8. Various industrial wastes.

Garbage is by far the most important of these waste materials; and its proper removal presents the greatest difficulty. In this country the word garbage describes those wastes of a putrescible nature which are produced in household, hotel, and restaurant kitchens. It also includes vegetable and animal wastes from markets, groceries, and similar establishments. Garbage has a commercial value which may be realized with proper treatment. A separate collection of this material is cus-

tomary. Owing to its putrescible character, its removal must be properly cared for or its decomposition will take place, resulting in the production of very offensive odors.

Rubbish is composed of a heterogeneous mixture of discarded materials and is largely of household origin. It is made up principally of paper, rags, wood, glass, crockery, bottles, tin cans, and numerous other wastes. The material as a whole has a commercial value which may be realized by separating those portions which are saleable. The collection of this class of material may or may not be separate; it is usual to find its collection combined with that of ashes.

Ashes may be considered as refuse from coal burned in furnaces, open grates, or under boilers. They may be classified as household or industrial ashes, according to their origin. The collection of household ashes is usually combined with that of rubbish, while industrial ashes are as a rule disposed of privately.

Street cleanings include that material removed from the surfaces of streets and alleys. It varies largely in composition with the locality and method of cleaning, but in the main consists of dirt from pavements, droppings from carts and animals, and at certain seasons of the year a variable percentage of leaves and rubbish.

Dead animals as a class of waste usually consist only of the larger animals, but in some cases where complete collection is made the classification includes also the smaller animals such as dogs, cats, etc.

Manure in a number of classifications has been included in trade refuse. It should, however, be considered a waste of domestic character and is demanding attention for municipal removal. It has a market value and a ready sale as fertilizing material.

Night soil is of a sewagic character in that its solid constituents are similar to those of sewage. It has, however, a very much lower moisture percentage and its consistency is more comparable to sewage sludge. It is a waste common to communities of every size but is rarely removed at municipal expense.

A number of classes of industries produce solid wastes which are to be included in municipal refuse. These are principally slaughter house offal, cellar excavations, material from building construction, etc., and are principally removed and disposed of by the individual.

A study of wastes disposal should properly include observations of the handling of material from the point of its origin to the point of its final disposal. The methods by which wastes are collected from dwellings, business establishments, streets and alleys, and conveyed to the points of disposal are of great importance, and in the minds of many the economic and sanitary features of this branch of the work are to be given more consideration than those of the method of disposal itself. This in a measure is a correct view, and no system of wastes disposal can be considered complete or satisfactory until there is provided an

adequate, well organized system of collection of wastes. Conversely, a proper method of disposal must be provided to complete satisfactory removal.

In carrying on the studies herein described, lack of funds and time prevented an extensive study of collection systems including observations of receptacles provided, frequency of collection, routing of wagons, length of haul, etc., and these data were obtained with only approximate accuracy from information furnished by local officials. The study of disposal of waste material in the various cities in Ohio was given considerable attention, and opportunity was had for observing disposal of garbage and dead animals by reduction, incineration, and burying; and of rubbish, ashes, and street cleanings, by dumping on land.

METHODS OF CONDUCTING FIELD AND LABORATORY EXAMINATIONS.

In carrying on the studies herein described, two principal features were kept in mind, namely, the character and quantity of waste material, and the methods and efficiency of collection and disposal. Of the nine cities in which the studies were made, only the four largest ones had well developed organizations of collection and disposal, although in each of the cities the collection of garbage was more or less properly cared for. In only three of the cities were there systems of rubbish and ashes collection, while in the other six there was no organization in this work. Street cleaning was found to be municipally carried on in each of the cities. In none of the cities, excepting Cleveland, did the municipality collect night soil, manure, or dead animals, and the private collection of these waste materials was in general carried on in an unorganized manner.

From these conditions it is apparent that no exhaustive studies could be made which would include each of the classes of waste material, and it was necessary to confine the studies to garbage, rubbish and ashes, and street cleaning. Owing to the impossibility of securing accurate data concerning the collection of night soil, manure, and dead animals, the studies of methods of removing these wastes were perforce confined to very general observations.

The studies of the character and quantity of wastes produced were carried on regularly in four of the largest cities of Ohio where data were available; but were not extensively carried on in the smaller cities. In each of the cities particular attention was given to the method of disposal, and in the smaller cities where disposal by burning was used, furnace tests were made with a view to studying the efficiency. The results of these studies are grouped and presented in Appendix II of this report under the heading, "The Disposal of Garbage by Incineration in Ohio." In these cities, observations of the collection of the material

and of its character and quantity, were made in connection with the tests conducted at the crematories; but no attempt was made to carry on extensive studies of these features. In a later portion of this report, detailed descriptions of the methods of conducting the furnace tests will be given. No attempt was made during the investigation to study the working efficiency of the reduction plants of the state, but as far as possible the results of the ordinary operating conditions were obtained.

The field studies in the larger cities of the state were carried on according to a schedule determined upon before beginning the examination. By this schedule it was provided that each city be visited one or more days each month and that upon two occasions a week's visit be made in each city. This schedule was followed out for each of the cities except Cincinnati where it was impossible to arrange for visits during the first few months of the studies. At that city, moreover, no arrangement could be made for a full week's visit. At each visit in the various cities, observations were made on the character and quantity of garbage, and a composite sample covering the day's collection was taken and shipped to Columbus for analysis. In Cincinnati, Cleveland, and Dayton, an additional day was employed during each visit in studying the character of the rubbish and ashes, and street cleanings collected. One of the dumps was selected for each visit, and all loads arriving there during the day were examined. In addition, one or more loads of rubbish and ashes were weighed and a mechanical analysis made of the material of each load, by which its different constituents were determined. All ashes arriving were sampled, and the composite shipped for analysis.

In addition to the actual field observations, department records and data were secured at each visit in the various cities.

Collection of Garbage Samples. Owing to the heterogeneous character of garbage, it is realized that the utmost care is required in securing a representative sample of the material delivered during any one day. The removal of a measured quantity from the cart or wagon before dumping, was first decided upon, but on trial this method was abandoned and it was decided in every case to obtain the sample after the load had been dumped. If a fair sample of the garbage from a load is to be secured, it is necessary to obtain not only a good mixture of the solid material but to also incorporate in the sample a proper amount of moisture before selecting the portion. This introduces a personal factor in the sampling which may permit of a wide variation in the various determinations, particularly in that of moisture. In Columbus, Dayton, and Cincinnati, the work of sampling was not difficult as easy access could be had to the material after it had been removed from the wagon body. At Cleveland, however, the samples were collected from the garbage cars immediately after the material had been dumped from the wagons at the loading station; the work was very difficult and when the dumping was congested, somewhat irregular. It was aimed to col-

Platform used for mixing garbage samples.

Ash shaker used for mechanical separation of ashes.

lect a sample totaling 500 pounds and this was possible in Dayton and Columbus, but was found to be impracticable in Cleveland and Cincinnati and a larger total sample was necessarily collected. From each load at Dayton a sample of about 15 pounds was taken; at Columbus, 10 pounds; and at Cincinnati and Cleveland, about 7 pounds. For preparation of the final sample a heavy wooden platform 6 feet square was provided and upon this the garbage sample was placed. By using sharp shovels or spades the material was finely divided until it became almost like a pulp. Any water which had drained from the mixing board was incorporated into the finely divided garbage and mixed thoroughly. After this the material was quartered and the process repeated until a sample of proper size remained. This was then placed in a large wide mouthed bottle and shipped to the laboratory at Columbus for analysis.

In chopping up the material, small pieces of wood, metal, rags, paper, cardboard, etc., were discarded from the sample. Owing to the difficulty of chopping, it also was necessary to discard large bones; the small ones which remained were broken up as much as possible, but it was difficult to preserve all the pieces within the mass as the tendency of the material was to scatter in all directions when broken with the shovel or other tool employed. The result of the loss of this constituent of the garbage is quite evident in all of the analyses for phosphoric acid. The irregularity of this constituent and the possible error in the moisture are perhaps both due to the difficulty of accurate sampling. It is thought, however, that sufficient accuracy of sampling was possible to insure the correctness of the determinations of the other constituents.

In connection with the sampling of garbage, accurate notes were made on each load. These notes included the source from which the material was collected; kind of receptacles used; the character of the district, whether high or low class residential, business, etc.; the appearance of the material, noting especially whether wet or dry, its principal constituents, and other noticeable features.

Field Examination of Rubbish and Ashes. The studies of the character of rubbish and ashes were confined to observation of loads delivered on the days of examination. From visual observation, notes were made on each load dumped. These notes contained as complete a description as possible of the constituents of the load. In addition, one or more were weighed each day of observation, and the contents separated into different classes of material. Each class was then weighed and the resultant mechanical analyses tabulated. The performance of these analyses was done by hired laborers and the completeness of the work varied considerably. The constituents picked from the load, namely, the paper, rags, etc., were so small in weight in comparison to the residue which was largely ashes and dirt, that only a small percentage error was introduced by a failure to secure complete separation. By this mechanical separation it was possible to obtain data upon the rela-

tive quantities of rubbish and ashes in the material. A small sample of ashes was taken from each load arriving during the day, and after mixing and quartering, the final sample was shipped to Columbus for analysis.

Laboratory Studies. In addition to the various observations made in the field, special attention throughout the examination was paid to obtaining analytical data in the study of the character of municipal wastes. For this purpose there was equipped and maintained at Columbus a complete laboratory supplied with special apparatus for conducting analyses of waste materials. An analyst was engaged constantly during the studies. To give an idea of the scope of the laboratory work, a total of 237 samples were submitted to examination. Of this total there were 139 garbage samples, 28 tankage samples, 36 composite ash samples, 8 street cleanings samples, 14 samples of garbage ash from crematories, 5 samples of fuel ash from crematories, and 7 samples of coal.

On all of the garbage and tankage samples, determinations were made for moisture, volatile and combustible matter, ash, calorific value, ether extract (grease), phosphoric acid, Kjeldahl nitrogen, and potash. In the street cleaning samples the same constituents were determined with the exception of ether extract. In the composite ash samples as well as the crematory ash samples, moisture, combustible matter, true ash, and calorific value were determined.

The methods of analysis in the main were adopted from those recommended by the Association of Official Agricultural Chemists. The methods for determination of phosphoric acid, nitrogen, and potash were those recommended by the association, and the methods for the other constituents were modified to meet conditions of the material analyzed. The procedure for moisture determination was studied somewhat during the progress of the work and for the last 50 samples was modified. Until April, 1910, samples 1 to 197, the procedure for moisture was as follows: A sample of about 2 pounds of the garbage was placed in an evaporating dish and heated at a temperature of boiling water until apparently dry. This required several days. It was then placed in a hot air oven and dried to constant weight at 100 to 105 deg. C.; the loss in weight was reported as moisture. The material was then ground in an iron mortar and bottled for future use. The laboratory studies demonstrated the fact that an appreciable amount of hygroscopic water was taken up in grinding, and after April in order to avoid the necessity of determining this content in connection with the future analysis the ground material was heated for about an hour at boiling temperature, at the end of which time it was bottled and tightly stoppered.

The volatile combustible matter was determined by usual methods, heating for a long period at the lowest possible temperature for combustion.

Ether extract, grease, or fats, as the constituent may be termed, was determined by the use of the Soxhlet extraction apparatus, 10 grams of the material being used for the determination.

The calorimetric determinations were made by the use of an Atwater bomb calorimeter, and all of this work was done after the chemical work in connection with the field studies had been completed. In this way the danger of variations introduced by the presence of heat in the laboratory was obviated.

ORGANIZATION AND MANAGEMENT OF DEPARTMENTS FOR CITY WASTES DISPOSAL.

In the larger cities of Ohio in which there has taken place an extensive development in the handling of waste material, the manner of organization of the departments under which the work is done is quite uniform. In each case in the large as well as in the smaller cities the department of public service has general supervision of the collection of wastes and of their disposal. For the four large cities, the following diagram will illustrate the organization.

DEPARTMENT OF PUBLIC SERVICE.

Supt. garbage collection.	Supt. garbage disposal.	Supt. street cleaning, rubbish, ashes, collection and disposal.
Asst. supt., foremen, clerks, laborers, etc.	Asst. supt., foremen, clerks, laborers, etc.	Asst. supt., foremen, clerks, laborers, etc.

This organization is varied somewhat at Cleveland and Dayton, where a general superintendent has charge of the sub-departments and is directly responsible to the department of public service. At Cincinnati the city maintains no garbage department, but the private collecting company operates under the supervision of the street clean department. In Columbus there is no department for the collection of rubbish and ashes. In the smaller cities of the state where studies were made, there was found to be little organization in the collection departments. In each of these cities, except Zanesville, private collection is carried on at the expense of the householder. This fact tends to place the collecting company or contractor out of the jurisdiction of the municipal officers, and these officials are consequently not generally familiar with the operations of the company. In these cities as in the larger ones, the disposal of garbage is under the public service department.

The historical facts connected with the development in garbage collection and disposal in the various cities in Ohio are of interest. In table No. 1 the main facts concerning the development in each of the cities studied are briefly given. It will be noted that the earliest development in municipal collection took place in Cincinnati in 1865,

[illegible]

TABLE NO 1—Concluded.

City.	Date of Installation of Disposal Plant.	Date of Organization of Private Collecting Company.	Date of Installation of Municipal Collection.	Remarks Concerning Collection.
Mansfield	1901	1901	none	Privately owned and operated by company, 1901-1908. Removal paid for by city. After 1908 removal paid for by individual.
Marion	1905	1906	none	Privately owned and operated company. No contract. Removal paid for by individual.
Steubenville	1907	1907	none	Municipal ownership. Collection by contractor. Removal paid for by individual.
Zanesville	1907	1908	1909	Privately owned and operated during 1908. Removal paid for by the city. Municipal collection 1909 to date.

The development in systems of street cleaning has in each of the cities preceded that of garbage collection, but on the other hand organized collection of rubbish and ashes has in every case, excepting at Cincinnati, developed subsequently to the organization of departments for the removal and disposal of garbage.

The earliest development in the organization of street cleaning departments was at Cincinnati. In this city municipal street cleaning was started in 1865, and the work has been continuously carried on by the city since that time. At Cleveland, Columbus, and Dayton, street cleaning has been done by the municipality for a number of years, and no evidence could be learned showing that the work had ever been carried on by private enterprise. At the present time each of the smaller cities of the state in which studies were carried on, maintains a fairly well equipped street cleaning department even where no provision has been made for municipal care of other wastes.

In the development of collection of rubbish and ashes, Cincinnati shows the earliest attention. In this city this work was started with the organization of the street cleaning department in 1865. In the other cities of the state, however, the development in this direction has been of recent growth. At Cleveland, organized collection of rubbish and ashes was undertaken by the city in 1906. At Dayton this work has been carried on by the city for but a few years. At Columbus and in

each of the five smaller cities, there has been no organization or municipal control of this work up to the present time. Development of a municipal system of collection of rubbish and ashes is in progress at Columbus and will no doubt be inaugurated in the near future.

EQUIPMENT AND METHODS OF COLLECTING AND HAULING CITY WASTES.

GARBAGE.

For the collection of garbage, particularly in the large cities of the state, special equipment suitable for the purpose is provided. Two general types of wagons are used. In Cleveland, Columbus, Cincinnati, Dayton, Steubenville, and Zanesville, covered steel tank wagon bodies are employed, and in the other cities studied the wagons are built with two platforms upon which the cans from the householders are placed directly. The Cleveland and Columbus wagons are of the same type and are designed for dumping their contents without removal of the wagon bodies. At Cincinnati and Dayton the wagon bodies are removed from the running gear and subsequently dumped after transportation to the point of disposal. The platform wagons used in connection with the so-called can system are somewhat less economical than the tank wagons but are entirely suited for small cities where the quantities of garbage are not great.

Rules governing the collection of garbage are similar in each of the cities where the work is organized. These rules apply particularly to the provision of proper receptacles, their location to facilitate removal, and where reduction plants are used the exclusion of rubbish and ashes from the garbage. Owing to the difficulty of rigid enforcement of the rules, they are in all of the cities violated to a greater or lesser degree, depending largely upon the character of the people.

In the smaller cities of the state the material is transported directly in the collection wagons to the disposal plants, but in the larger cities where the question of length of haul becomes of great importance there have been established loading stations where the garbage may be dumped into specially constructed cars or left in the wagon bodies which are placed on flat cars and thus transported to the point of final disposal. This method is practiced in each of the large cities in Ohio.

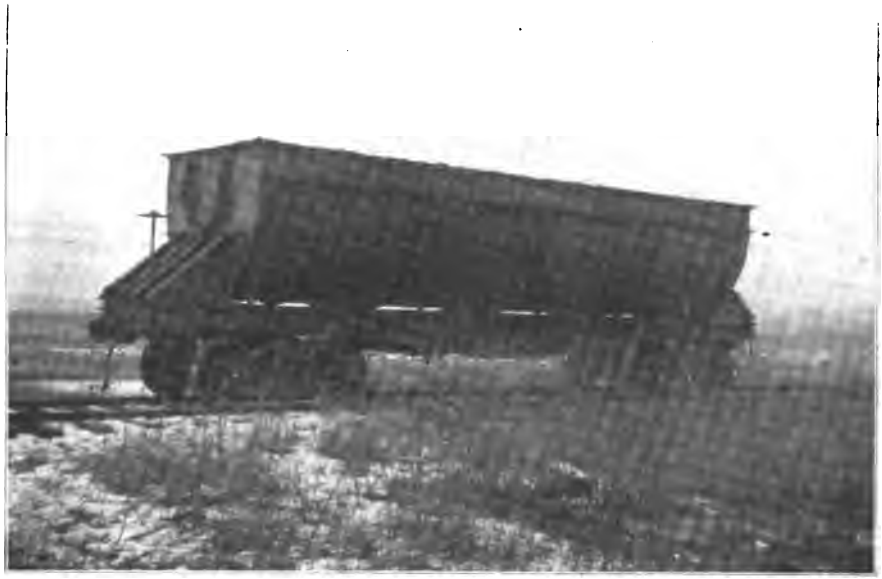
RUBBISH—ASHES.

Although separate collection of rubbish and ashes is practiced in certain localities, it was found that in each of the Ohio cities in which this work is carried on these wastes are collected and disposed of together. In only three of the cities of the state are there organized col-

Old type of Columbus collection wagon.

Type of garbage collection wagon used at Mansfield, Marion and Canton.

Type of garbage collection wagon used at Columbus and Cleveland.



Type of garbage car used at Cleveland and Columbus.

Dumping garbage in cars at Cleveland.

lection systems for this class of material, and in each of the others private scavengers are depended on. Special types of wagons are used at Cincinanti and at Cleveland, while at Dayton a modification of the slat board type of wagon is employed. Local conditions are met at Cincinnati by the use of a back dump wagon manufactured by the city street cleaning department, and at Cleveland by the use of a bottom dump wagon of standard make. The type of wagon is not of vast importance but it seems to be the consenus of opinion that for best economic results the wagon should have a capacity of from three to four cubic yards where combined collection of ashes and rubbish is made.

As is the case with garbage collection, rules have been adopted in each of the cities regulating the collection of rubbish and ashes. Such rules in general provide for the receptacles to be used, the preparation of the material to facilitate collection, and the exclusion of garbage and other offensive material from the ashes and rubbish. These rules are generally enforced, but the difficulty in accomplishing this permits of more or less violation.

Aside from the equipment for removal of rubbish and ashes from households, city departments maintain minor equipment consisting of waste paper boxes and baskets located in streets and parks. This development has taken place in each of the large cities of the state and does much toward promoting the cleanliness of those cities. Where no rubbish collection is made, the street cleaning department attends to the removal of the waste paper thus accumulated.

STREET CLEANINGS.

In each of the cities of Ohio in which studies were made, there are municipal street cleaning departments more or less efficiently equipped. In the smaller cities the equipments are less adequate and in a state of more incomplete development than in the larger ones, and for this reason the studies were confined to observations in Cincinnati, Cleveland, and Columbus. In each of these cities well equipped departments are maintained and efficient work is accomplished.

The equipment of the street cleaning departments in these cities in general consists of flushing machines, machine sweepers, sprinkling carts, white wing outfits for hand cleaning, and wagons for the removal of street and catch basin dirt. The kind of equipment in the three cities varies with the method of cleaning practiced, the relative proportion of flushers, machine sweepers, etc., being dependent upon the relative amounts of cleaning done by the different methods.

There were found to be practiced three general methods of street cleaning; namely, flushing, machine sweeping, and hand cleaning. Flushing is carried on by the use of flushing machines alone as at Cleveland and Columbus, or by the use of flushing machines supplemented by ma-

chine sweepers as at Cincinnati. Machine sweeping is usually accomplished by the use of sprinkling carts and the old type of machine sweepers with a revolving broom. The practice at Cincinnati modifies this to the extent of substituting the flushing machines for the sprinkling carts. The hand cleaning method consists of the removal of the material from the surface of the streets by hand labor; brooms, shovels, and scrapers being employed. The street may or may not be sprinkled previous to cleaning.

At Cleveland and Cincinnati the street cleaning departments are especially equipped to carry on cleaning by flushing. At Cleveland machine sweeping has been almost entirely discarded and is now used to only a very small extent. At Cincinnati, however, the old equipment of the department, consisting principally of machine sweepers, has been retained to be used in conjunction with the flushing machines. In both of these cities hand cleaning is also an important method in use, and records indicate a greater area cleaned by this means than by any other method. At Columbus the equipment of the street cleaning department allows a relatively small amount of the work to be carried on by flushing, and in that city the machine sweeping method is the most important.

In table No. 2 are given figures representing the total areas cleaned by the different methods at Cincinnati, Cleveland, and Columbus. A study of this table will indicate the relative importance of the different methods as well as show the extent of the work of the street cleaning departments.

TABLE NO. 2.

AREAS CLEANED BY VARIOUS METHODS OF STREET CLEANING 1909-1910.

Great Squares (10,000 sq. ft.)

Cincinnati. 1909.		Cleveland. 1909.		Columbus. 1910.	
Flushers and machine sweepers..	126,439	Flushers	54,475	Flushers	18,221
		Machine sweepers..	605	Machine sweepers.	88,516
Hand cleaning....	195,144	Hand cleaning....	318,800	Hand cleaning....	84,024
Total	321,583	Total	373,880	Total	190,761

Whatever method of street cleaning is employed, it is necessary to remove the material collected in the gutters by the use of carts or wagons. Where machine sweeping or hand cleaning is done, this is usually accomplished soon after the material has been removed from the surface. When flushing is used, it is necessary to allow a number of hours to elapse to permit drainage and partial drying of the material in order that it may be handled with facility. The wagons provided are of special type in each of the cities, equipped with dumping appliances to suit local conditions.

Type of rubbish wagon used at Columbus and Cleveland.

Cincinnati — Motor truck for transfer of rubbish and street cleanings from loading station to dump.

Columbus — Type of wagon used for manure collection.

CHARACTER OF WASTE MATERIALS.

In the observations made in connection with the study of city wastes disposal, a particular effort was made to learn the character and the quantities of the various wastes. The character of the waste materials was studied largely by visual observation, but the chemical characteristics were also learned by means of laboratory determinations. The visual observations were made in the field, while the chemical determinations were made upon samples shipped to the laboratory. The study of the character of waste materials was confined to garbage, rubbish, ashes, and street cleanings; the other classes of city wastes being neglected owing principally to the unorganized systems of collection of these classes.

GARBAGE.

Physical Characteristics. The physical characteristics of the garbage of the different cities were studied by means of observations made on one or more occasions each month during the investigation. It was realized before attempting the studies that the physical characteristics were subject to fluctuations brought about by a number of factors, the most important of which was the seasonal variation. In addition to the seasonal variation, the physical characteristics are subject to changes due to the source of the material, its moisture content, the time which has elapsed since the previous collection, the admixture of rubbish and other foreign material, and other numerous factors. Considering the heterogeneous character of garbage and the conditions which tend to affect its appearance, it is evident that any attempt to completely describe the material is extremely difficult. In the observations made it was therefore aimed to note only the principal characteristics of the material, such as its relative moisture content and the most noticeable wastes contained.

By means of these general observations on the appearance of the garbage, it was found possible to roughly classify the material in each of the cities into five general classes. These for convenience have been designated classes A, B, C, D, and E.

Class A garbage represents residential garbage collected from what may be termed high class residential districts. Its appearance was very similar in each of the cities studied, but it was more subject to the seasonal fluctuations than any other class of garbage. Its general appearance was fresh and clean and it was usually found to contain a large proportion of fresh fruit and vegetable refuse.

Class B garbage typifies that material produced by what may be termed medium class residences. It is of practically the same appearance in the different cities of the state and is with difficulty differentiated from class A garbage except in the fact that it has a somewhat less fresh and clean appearance.

Class C represents that garbage collected from the low class and

tenement districts. It is easily distinguished from other classes of garbage because of its marked dirty and old appearance. This class is similar in each of the cities of Ohio but its unpleasant appearance is emphasized where the district from which it is collected is given infrequent attention. In this class of garbage it is customary to find an admixture of all sorts of foreign materials.

Class D refers to kitchen wastes from hotels, restaurants, and eating houses. It is readily distinguished from residential garbage by the fact that it contains a large quantity of cooked vegetable wastes, has a wetter appearance, and is noticeably high in grease content. It usually contains the same fresh vegetable wastes found in class A garbage, but in smaller percentages.

Class E refers to those wastes collected from market houses, commission houses, groceries, etc. This material generally consists of purely vegetable or fruit wastes and may also contain a rather large proportion of rubbish. It is seldom wet in appearance.

In accordance with the foregoing arbitrary classification, an attempt was made to separate into the various classes the loads observed in the different cities on the days of sampling. The accompanying diagrams in figure No. 1 have been drawn to represent the percentages of the total loads observed in each city represented by the different classes of garbage. It will be seen that a fair agreement exists in the diagrams for the different cities, and the average curve for the four cities does not depart materially from the curve for any one of them. It will be seen that the residential garbage in the four cities is made up of about 23 per cent class A, 57 per cent class B, and 20 per cent class C. The percentages of the non-residential garbage, class D and class E, fluctuate widely for the different cities, and this is largely due to local conditions affecting its collection.

In addition to the appearance of garbage, its weight must be considered in a study of its physical characteristics. With no free water throughout the mass, the weight of a unit volume of the material should be entirely dependent upon the character of its composition and upon its compactness. These two factors of course influence the weight of the material, but the principal fluctuation is brought about by the presence of free water which partially fills the voids in the mass. The moisture content of garbage that includes this free water is in turn dependent upon the weather conditions previous to collection, the kind and condition of receptacles used, and the general tendency among the people to include or exclude waste liquors with the garbage.

In two of the cities, namely, Cincinnati and Cleveland, a daily record of the weight of the material is kept by the garbage collection departments, and knowing its volume its unit weight is readily calculated. In each of the cities it was aimed, however, to obtain the actual weight

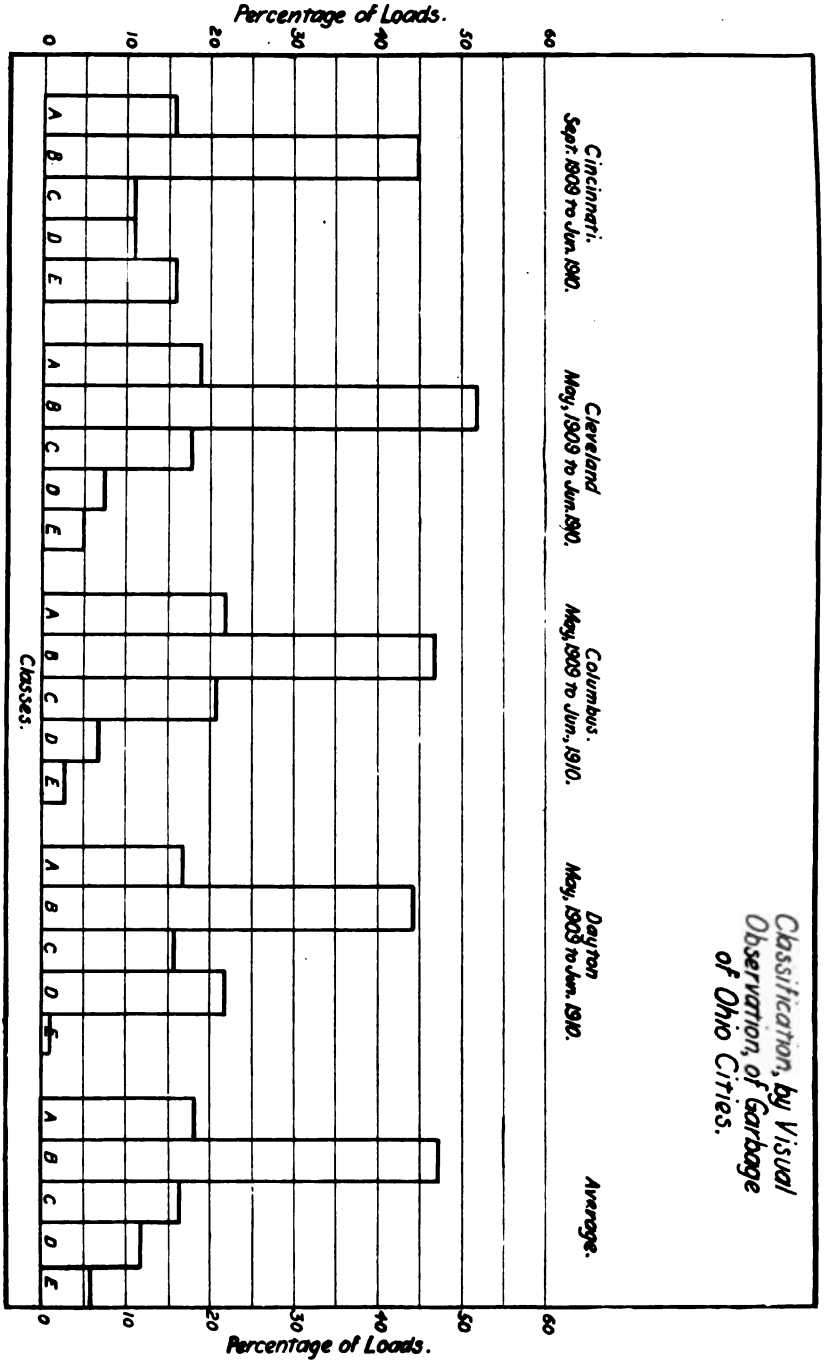

Classification, by Visual Observation, of Garbage of Ohio Cities.
Percentage of Loads.
0
10
20
30
40
50
60
Cincinnati. Sept. 1909 to Jun. 1910.
Cleveland May, 1909 to Jun. 1910.
Columbus. May, 1909 to Jun., 1910.
Dayton May, 1909 to Jun. 1910.
Average.
A
B
C
D
E
Classes.

FIGURE No. 1.

of the garbage on the days of sampling, and in Columbus and Dayton this information was used in calculating the unit weight of the material.

In table No. 3 is presented the average weight of garbage per cubic yard for the different cities in Ohio.

TABLE NO. 3.

AVERAGE WEIGHT OF GARBAGE PER CUBIC YARD.

Locality.	Average Wt. per Cu. Yd.	Period.	Average Per Cent. Moisture.	Remarks.
Cincinnati*	1227	Sept. '09-June '10 ..	76.6	Wagon weights at loading station. Average of week of sampling.
Cleveland†	1333	May '09-June '10...	75.6	Railroad car weights, sampling day.
Columbus	1173	May '09-June '10...	76.4	Wagon weights on route, sampling day.
Dayton	1475	July '09-June '10...	80.6	Wagon weights at loading station, sampling day.

* Average weight per cu. yd., Sept. 1909-June 1910, local records, 1225.
† Average weight per cu. yd., May 1909-June 1910, local records, 1367.

The fluctuations in the unit weight of the material during the periods for which data were collected are presented graphically by diagrams in figure No. 2. At Cincinnati, it will be noted that the unit weight is at its maximum during the summer months and at its lowest point during the winter season. This is also true although not so noticeably in the diagrams for the other cities. The low figures during January, February, and March, 1910, at Columbus, are brought about by the extremely cold weather on the days of sampling. The material was delivered in a frozen condition and was consequently very much less compact than is the usual condition. It is interesting to note the effect of excessive moisture content upon the unit weights at Dayton.

Composition of Garbage. The composition of the garbage of Cincinnati, Cleveland, Columbus, and Dayton, was studied by laboratory determinations for its most important characteristics. It was hoped to learn the distinctive features of the garbage from the different cities as well as the variation throughout the year. The results of all of the analytical data thus secured are presented in an appendix to this report.

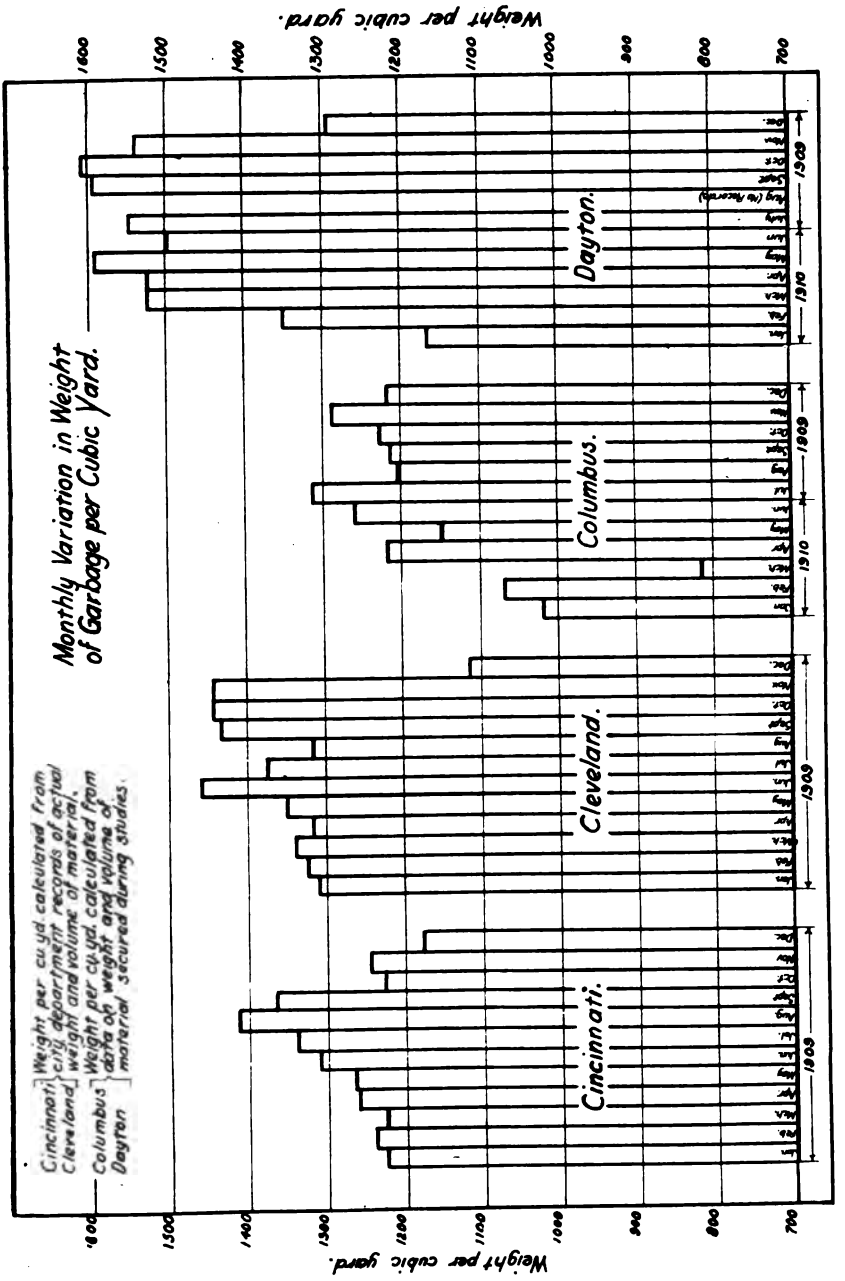

Monthly Variation in Weight of Garbage per Cubic Yard.
Weight per cubic yard.
Cincinnati
Cleveland
Columbus
Dayton
Weight per cu.yd. calculated from city department records of actual weight and volume of material.
Weight per cu.yd. calculated from data on weight and volume of material secured during studies.
Cincinnati.
Cleveland.
Columbus.
Dayton.
1908
1909
1910

FIGURE NO. 2.

In table No. 4 are given the average, maximum, and minimum results of determinations for the various constituents of the garbage of the different cities. These results are also presented in table No. 5 calculated to the dry basis. For purposes of comparison the results on the dry basis are of more value in indicating the composition of the solid matter of garbage than the actual determinations on a wet basis. An examination of tables Nos. 4 and 5 will indicate the regularity in the average results and the similarity of the garbage from each of the cities. What differences exist may have been caused by improper sampling or unsuitable sampling days. The phosphoric acid determinations are known to be lower than the actual content, and this is due entirely to the impossibility of securing a representative sample. By excluding large bones, etc., appearing in the sample, upwards of fifty per cent of the phosphoric acid was lost.

With the marked seasonal variation in the appearance of garbage, it it natural to expect that a variation in the composition of the material also exists. It was with the view of demonstrating the seasonal variation in the composition of garbage that the schedule of sampling extending over a period of one year was decided upon.

The seasonal variation in certain characteristics of garbage, namely, its percentage of moisture, ash and combustible matter, and its calorific value, is well shown in the results of the laboratory studies. This variation, while not so apparent in the results for any one locality, is illustrated in the averages of the results for the four cities of Ohio. In figure No. 3 are diagrams representing the monthly variation in the average determinations for Cleveland, Cincinnati, Columbus, and Dayton, of certain characteristics of garbage.

The diagram for moisture shows that the maximum is reached during the summer months, the determinations for the different cities having their high points in August and September. On the other hand the minimum moisture content occurs during the late winter and spring months. Corresponding to this fluctuation of moisture, the percentages of ash and combustible matter and the calorific value are at their minimum during the summer months and at their maximum during the late winter and spring months.

In figure No. 4 are diagrams presenting graphically the variation in percentages of ash and combustible matter and of calorific value. In these diagrams the values of figure No. 3 are calculated to the dry basis, by which the effect of moisture fluctuation is avoided. It will be seen in the diagrams of figure No. 4 that but a slight variation occurs throughout the year in the values of the constituents in the dry material. The ash diagram shows a tendency of lower percentages during the winter months, while the combustible matter is somewhat higher at that season. The calorific values follow the percentages of combustible matter quite regularly.

TABLE NO. 4.

SUMMARY OF ANALYSES OF GARBAGE OF OHIO CITIES.

	Cincinnati.			Cleveland.			Columbus.			Dayton.		
	10 Samples. [a]			28 Samples. [b]			31 Samples [c]			30 Samples. [d]		
	Sept. 1909 - June 1910.			May 1909 - June 1910.			May 1909 - June 1910.			May 1909 - June 1910.		
	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.
Per cent Moisture.....	76.6	79.3	74.5	75.6	78.9	72.7	76.4	79.7	73.2	80.6	83.3	78.2
Per cent Ash	3.66	4.80	3.01	3.20	4.02	2.63	3.30	4.61	2.43	2.57	3.39	1.96
Per cent Combustible Matter..	19.70	20.78	17.67	21.16	23.84	18.26	20.27	23.12	17.26	16.82	19.01	14.74
Calorific Value B. T. U.....	2000.	2215.	1771.	2057.	2264.	1808.	1994.	2289.	1679.	1712.	1927.	1488.
Per cent Ether Extract.....	4.02	5.46	3.22	3.85	4.54	2.89	3.96	5.12	3.03	3.83	4.76	2.98
Per cent Phosphoric Acid P_2O_5.	0.29	0.36	0.17	0.24	0.34	0.18	0.22	0.32	0.09	0.19	0.29	0.15
Per cent Kjeldahl Nitrogen....	0.64	0.72	0.57	0.64	0.73	0.53	0.59	0.72	0.47	0.51	0.60	0.41
Per cent Potash K_2O.....	0.28	0.34	0.21	0.30	0.35	0.25	0.25	0.32	0.18	0.20	0.29	0.13

NOTES.

a Ten regular monthly samples.

b Including four duplicate samples and twelve samples collected during two weeks' sampling, June 15-21, 1909 and Dec. 13-18, 1909.

c Including eight duplicate samples and eleven samples collected during two weeks' sampling, June 1-5, 1909 and Nov. 29-Dec. 4, 1909.

d Including seven duplicate samples and eleven samples collected during two weeks' sampling, July 12-19, 1909 and Jan. 10-15, 1910.

TABLE NO. 5.

SUMMARY OF ANALYSES OF GARBAGE OF OHIO CITIES.

Results Calculated to Dry Basis.

	Cincinnati.			Cleveland.			Columbus.			Dayton.		
	10 Samples.[a]			28 Samples.[b]			31 Samples.[c]			30 Samples.[d]		
	Sept. 1909 - June 1910.			May 1909 - June 1910.			May 1909 - June 1910.			May 1909 - June 1910.		
	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.
Per cent Ash	15.65	20.35	12.71	13.12	15.06	10.90	13.98	17.66	10.56	13.19	16.15	11.50
Per cent Combustible Matter	84.35	87.29	79.66	86.88	89.10	84.94	86.02	89.44	82.34	86.81	88.50	83.85
Caloritic Value B. T. U.	8558.	9186.	8272.	8459.	8755.	7883.	8448.	8839.	8194.	8776.	8928.	8179.
Per cent Ether Extract	17.15	22.64	14.52	15.85	20.72	12.53	16.74	19.06	14.53	19.77	24.41	16.15
Per cent Phosporic Acid P_2O_5	1.26	1.91	0.71	0.99	1.38	0.65	0.95	1.63	0.41	1.00	1.42	0.72
Per cent Kjeldahl Nitrogen	2.74	2.92	2.53	2.61	2.84	2.37	2.50	2.93	2.23	2.65	2.96	2.30
Per cent Potash K_2O	1.18	1.34	0.88	1.23	1.49	1.06	1.08	1.34	0.78	1.03	1.42	0.68

NOTES.

a Ten regular monthly samples.

b Including four duplicate samples and twelve samples collected during two weeks' sampling, June 15-21, 1909 and Dec. 13-18, 1909.

c Including eight duplicate samples and eleven samples collected during two weeks' sampling, June 1-5, 1909 and Nov. 29-Dec. 4, 1909.

d Including seven duplicate samples and eleven samples collected during two weeks' sampling, July 12-19, 1909 and Jan. 10-15, 1910.

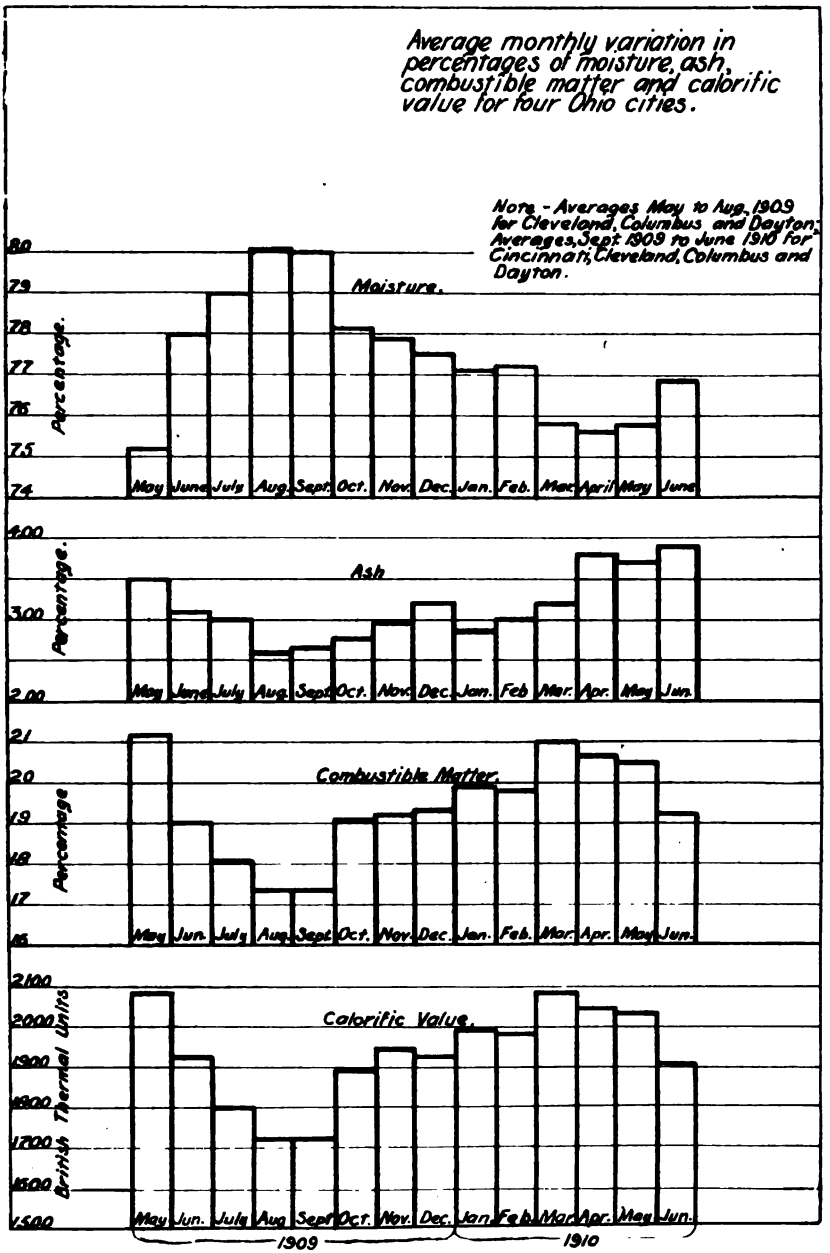

Average monthly variation in percentages of moisture, ash, combustible matter and calorific value for four Ohio cities.
Note - Averages May to Aug. 1909 for Cleveland, Columbus and Dayton; Averages, Sept. 1909 to June 1910 for Cincinnati, Cleveland, Columbus and Dayton.
Moisture.
Percentage.
80
79
78
77
76
7.5
74
May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. April May June
Ash
Percentage.
4.00
3.00
2.00
May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb Mar. Apr. May Jun.
Combustible Matter.
Percentage
21
20
19
18
17
16
May Jun. July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May Jun.
Calorific Value.
British Thermal Units
2100
2000
1900
1800
1700
1600
1500
May Jun. July Aug Sept Oct. Nov. Dec. Jan. Feb. Mar. Apr. May Jun.
1909
1910

FIGURE No. 3.

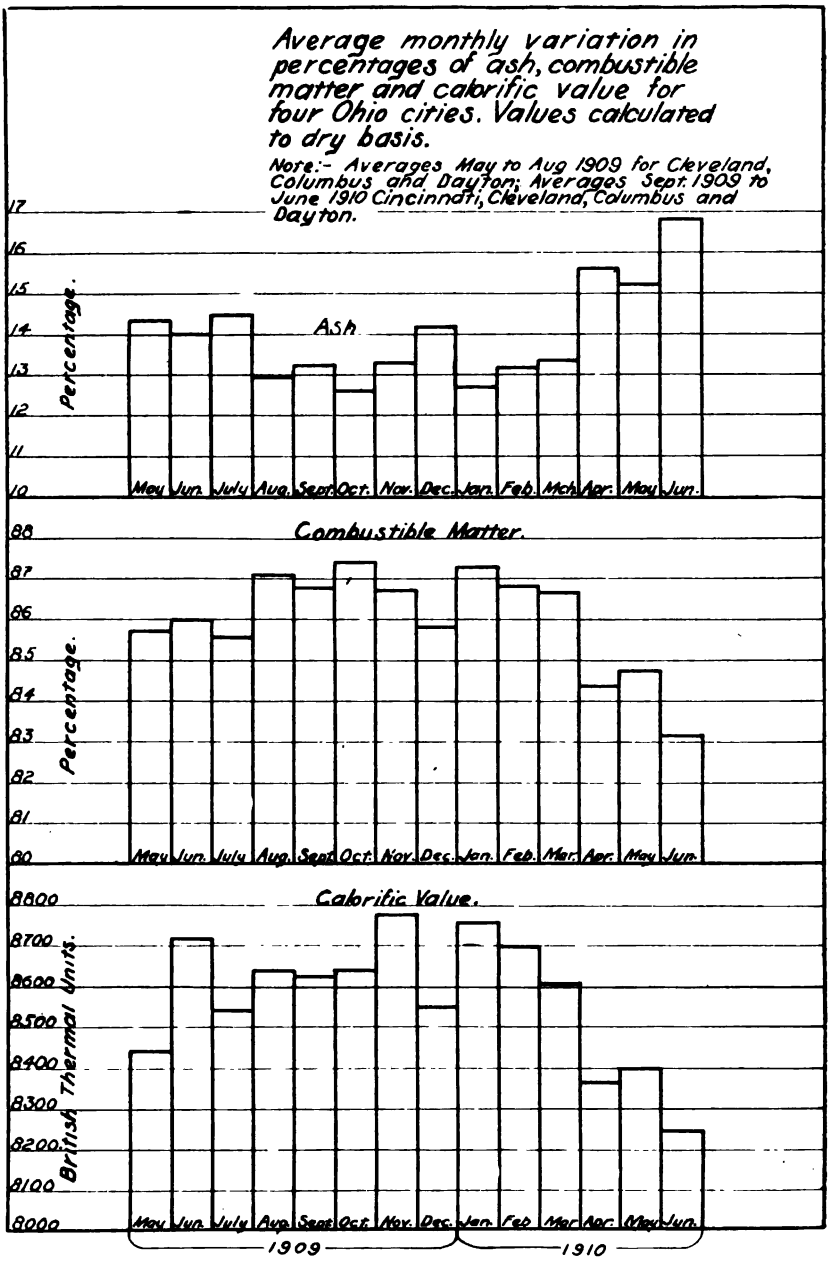

Average monthly variation in percentages of ash, combustible matter and calorific value for four Ohio cities. Values calculated to dry basis.
Note:- Averages May to Aug 1909 for Cleveland, Columbus and Dayton; Averages Sept. 1909 to June 1910 Cincinnati, Cleveland, Columbus and Dayton.
Ash
Percentage.
17
16
15
14
13
12
11
10
Combustible Matter.
Percentage.
88
87
86
85
84
83
82
81
80
Calorific Value.
British Thermal Units.
8800
8700
8600
8500
8400
8300
8200
8100
8000
May Jun. July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mch. Apr. May Jun.
1909
1910

FIGURE NO. 4.

The variation in certain of the chemical constituents of garbage as determined by analyses of composite samples, is presented graphically by diagrams in figure No. 5. The values for these diagrams are calculated upon the dry basis, by which the effect of fluctuations in the moisture content is avoided.

It will be seen that the ether extract diagram shows no accountable variation in this constituent throughout the year. The phosphoric acid percentages are all low due to inaccurate sampling, and the diagram illustrates no valuable data concerning the fluctuation of this constituent. The nitrogen diagram shows small fluctuation, the only noticeable variation occurring in August when the minimum percentages for each of the cities were found. The potash diagram is fairly regular but exhibits generally lower percentages during the winter months.

Taking the results as a whole, it will be seen that the analytical determinations for ether extract, phosphoric acid, nitrogen, and potash, fail to indicate a regular or accountable seasonal variation in these constituents. This fact does not show conclusively that such variation does not exist, and the failure to indicate it is probably due to two principal reasons. The sampling day selected each month may not have been representative of the average character of the garbage for that month; and the difficulty of securing a fair sample of the material may have prevented the securing of evidence of the seasonal variation. Considering this failure to demonstrate the seasonal variation in these constituents, it appears that the principal value of the results must be derived from the averages.

RUBBISH AND ASHES.

The study of the character of each of these wastes was rendered difficult owing to the fact that in no city in Ohio are they collected separately. Furthermore, it was in no case possible to make complete observations on all of the material removed from any of the cities on a particular day, owing to the fact that several points of disposal are used in each city. It was, therefore, necessary to select for study and visit but one dumping point at a time and to make observations on the material delivered there during the day. The visual observations were valuable in indicating the general character of the material, but accurate information was obtained by actual mechanical analyses of the material made in the field. By means of these analyses, the rubbish in those loads examined was separated from the ashes, and the rubbish was further separated into various component portions.

As the opportunity was offered, during the study of the character of rubbish and ashes, loads of the material were weighed. The weighed loads were generally those which were submitted to separation and chemical analyses; and it was found that the composition of the material had an effect on its unit weight. The average weight of ashes per cubic

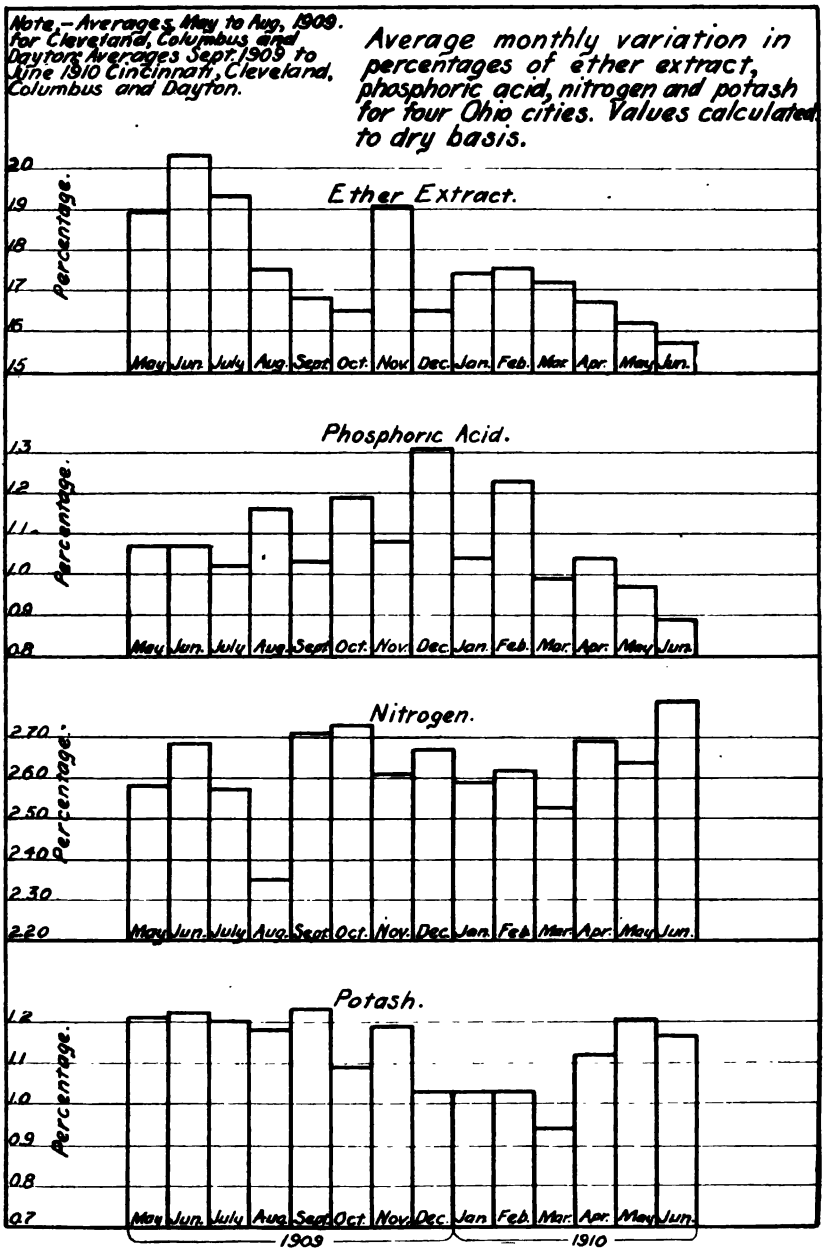

Note.—Averages May to Aug. 1909. for Cleveland, Columbus and Dayton. Averages Sept. 1909 to June 1910 Cincinnati, Cleveland, Columbus and Dayton.
Average monthly variation in percentages of ether extract, phosphoric acid, nitrogen and potash for four Ohio cities. Values calculated to dry basis.
Ether Extract.
Percentage.
20
19
18
17
16
15
Phosphoric Acid.
1.3
1.2
1.1
1.0
0.9
0.8
Nitrogen.
2.70
2.60
2.50
2.40
2.30
2.20
Potash.
1.2
1.1
1.0
0.9
0.8
0.7
May Jun. July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May Jun.
1909
1910

FIGURE NO. 5.

yard is given by H. deB. Parsons (The Disposal of Municipal Refuse, 1906) as 1350 pounds, and of rubbish as 200 pounds. A mixture of these two classes of waste will vary between these figures, depending on the relative percentages of each.

In table No. 6 are given figures representing the average weight per cubic yard of mixed rubbish and ashes at Cincinnati, Cleveland, and Dayton. The figures for Cleveland and Dayton are obtained by averaging all of the weighed loads, while the value for Cincinnati is a weighted average taking into account the heavy winter collection of ashes. In the two former cities, seasonal variation in the weight of the material does not occur, but at Cincinnati the unit weight during the winter months is greatly increased by the presence of a large percentage of ashes. The moisture content of the ashes also plays an important part in determining the unit weight, and this is shown in the data presented in table No. 6.

TABLE NO. 6.

AVERAGE WEIGHT OF RUBBISH—ASHES PER CUBIC YARD.

	No. Loads Weighed.	Av. Wt. per Cu. Yd. lbs.	Period.	Av. per cent Moisture in Ashes.	Aver. per cent Ashes.	Aver. per cent Dry Ashes.
Cincinnati	36	786*	May 1909-June 1910.	7.8	81.5	73.7
Cleveland	18	834	May 1909-June 1910.	14.1	84.1	70.0
Dayton	15	1090	May 1909-May 1910.	19.3	90.7	71.4

*Weighted average: Jan., Feb., Mar., Dec., 935 lbs. per cu. yd.
April to Nov. 682 lbs. per cu. yd.

A summary of the separation of the rubbish and ashes during the studies is presented in table No. 7. In this table the figures are on a basis of weight. It will be seen that in each of the cities the ashes constitute the bulk of the material, the rubbish making up but a small percentage of the weight. The rather low percentage of rubbish in Cleveland, a city in which gas is the principal fuel, in comparison to Cincinnati in which coal is generally used, is brought about principally by the fact that at Cleveland the city is engaged in a separate collection of waste paper, which it is well known constitutes an appreciable percentage of the rubbish.

At Cincinnati the rubbish collected is of much greater quantity relatively than that collected at either Dayton or Cleveland. The apparent percentages of ashes as given in table No. 7 are moreover affected by the moisture content of the ashes. If the average percentages of moist-

ure for Cincinnati, Cleveland, and Dayton, are deducted from the average percentages of ashes in table No. 6, the average percentages of dry ashes from the three cities become—Cincinnati, 73.7 per cent; Cleveland, 70.0 per cent; and Dayton, 71.4 per cent.

TABLE NO. 7.

SUMMARY OF PERCENTAGES OF RUBBISH AND ASHES.

	No. loads separated.	Period.	Per cent Rubbish.			Per cent Ashes.		
			Av.	Max.	Min.	Av.	Max.	Min.
Cincinnati	26	May 1909-June 1910	18.5	28.6	4.9	81.5	95.1	71.4
Cleveland	10	May 1909-June 1910	15.9	30.0	9.4	84.1	91.6	70.0
Dayton	15	May 1909-May 1910	9.3	20.2	4.9	90.7	95.1	79.8

The seasonal fluctuation in the character of rubbish and ashes is shown principally in the variation in the relative amounts of rubbish and of ashes in the material. Only at Cincinnati, however, is the fluctuation apparent. Here the percentage of ashes is at a maximum during the winter months and at a minimum during the summer season. This is the natural result when coal is extensively used as a fuel. At Cincinnati the summer material is made up in volume of approximately 35 per cent ashes and 65 per cent rubbish, and during the winter months of 75 per cent ashes and 25 per cent rubbish. At Cleveland and Dayton slight seasonal fluctuation occurs in the relative percentage of ashes and rubbish, and the material is of fairly regular composition throughout the year.

Rubbish. Rubbish consists of that portion of household waste which cannot be included in a classification of garbage or ashes. It may contain any discarded article but its principal and most noticeable constituents are paper, rags, wood, tin cans, glass, crockery and bottles. In itself it is without objectionable odor and does not decompose and become offensive. When it contains even a small amount of garbage or other putrescible material, the mass as a whole becomes odorous and objectionable. In table No. 8 are presented summarized analyses of rubbish from Cincinnati, Cleveland, and Dayton. These figures give the relative percentages of the different constituents of the true rubbish portions of the load separated, neglecting the ashes portion which constitutes the principal part of the load. The seasonal variation of the character of the rubbish was not demonstrated, and there is no reason to believe that such variation exists.

TABLE NO 8.

AVERAGE COMPOSITION OF RUBBISH.

May, 1909–June, 1910.

	Cincinnati.	Cleveland.	Dayton.
No. Loads	26	10	15
Paper (per cent)	40.3	28.9	16.4
Rags	6.7	7.6	6.2
Wood	7.2	13.6	17.0
Tins	15.9	18.6	26.3
Iron	2.5	3.6	5.1
Other metal	.....	1.1	1.3
Bottles —			
Weight	6.3	5.7	8.4
Number	28	38	56
Broken glass and crockery	11.0	14.2	12.7
Leather	2.4	2.3	3.0
Garbage —			
Bones	0.6	1.1	0.5
Other garbage	7.0	3.2	2.9

Ashes. The ashes municipally collected at Cincinnati, Cleveland, and Dayton, in connection with the rubbish collection, are almost entirely of household origin. Steam ashes or those produced in industrial power plants are as a rule not disposed of on the city rubbish dumps. They are in all cases privately cared for, and their handling does not constitute a problem for the municipality. A study of the character of the ashes in the different cities was confined to the collection of composite samples from the loads received during one day and the subsequent mechanical and laboratory analyses of the material. The mechanical analyses consisted in separation by means of a ⅜-inch mesh screen, of the fine material from the clinker and unburned coal. The relative proportions of clinker and unburned coal were also determined by separation. In table No. 9 the average results of the mechanical analyses of ashes from the three cities are given. By recalculating the results to indicate the relative percentages of unburned coal and clinkers and cinders which might be separated from the fine material by screening, the results in table No. 10 were obtained.

TABLE NO. 9.

SUMMARY OF MECHANICAL ANALYSES OF COMPOSITE SAMPLES OF HOUSEHOLD ASHES.

	Number of Analyses.	Period.	Percentages.		
			Unburned Coal.	Clinkers and Cinders.	Fine Material.
Cincinnati	7	May 1909-June 1910.	24.4	6.6	69.0
Cleveland	4	May 1909-June 1910.	19.5	15.6	64.9
Dayton	7	May 1909-June 1910.	21.1	12.7	66.2

TABLE NO. 10.

SUMMARY OF RELATIVE PERCENTAGES OF UNBURNED COAL AND CLINKERS AND CINDERS.

(Results calculated from those of Table No. 9.)

	Number of Analyses.	Percentages.	
		Unburned Coal.	Clinkers and Cinders.
Cincinnati	7	78.7	21.3
Cleveland	4	55.5	44.5
Dayton	7	62.5	37.5

The laboratory analysis of ashes consisted in determining moisture, combustible, ash, and calorific value. The moisture content is largely dependent upon the exposure of material to the weather previous to collection, and therefore to present more comparable figures, those of table No. 11 are recalculated on the dry basis and presented in table No. 12.

TABLE NO. 11.

SUMMARY OF ANALYSES OF COMPOSITE SAMPLES OF ASHES.

	Number Analyses.	Period.	Percentages.			Calorific Value.
			Moisture	Combustible Matter.	Ash.	
Cincinnati	7	May 1909-June 1910...	7.8	30.5	61.7	3087
Cleveland	6	May 1909-June 1910...	14.1	22.0	63.9	1815
Dayton	9	May 1909-June 1910...	19.3	21.5	59.2	2517

TABLE NO. 12.

RESULTS OF TABLE NO. 11 CALCULATED TO DRY BASIS.

	Number Analyses.	Period.	Percentages.		Calorific Value.
			Combustible Matter.	Ash.	
Cincinnati	7	May 1909-June 1910.....	33.1	66.9	3348
Cleveland	6	May 1909-June 1910.....	25.6	74.4	2113
Dayton	9	May 1909-June 1910.....	26.6	73.4	3119

The examinations of ashes in general show that the material as collected contains 30 to 35 per cent of coarse material which may be separated from the fine portion by screening. Approximately 50 to 80 per cent of this coarse material, or 20 to 25 per cent of the ashes as a whole, consists of unburned coal which has a fuel value. This fuel value may or may not warrant the separation of the unburned material from the ashes.

STREET AND CATCH BASIN CLEANINGS.

The opportunity to study the character of this class of city waste was limited to observation of its appearance at the dumps in the various cities and to chemical analyses of a small number of samples collected. The character of the material removed from the surface of streets depends upon the kind of pavement and upon the method as well as frequency of cleaning. Without making an extensive study, it was im-

possible to learn accurately the effect of these factors upon the character as well as the quantity of the material removed.

As previously described, there are in use three general methods of street cleaning in Ohio, namely, flushing, hand cleaning, and machine cleaning. When the street is flushed, water is applied at a considerable velocity which carries the material to the gutters, and a large proportion which is held in suspension in the water enters the catch basins. This method cleans a smoothly surfaced street almost perfectly, but the material which is removed by wagons subsequent to the flushing is comparatively small in amount, due to the fact that such an appreciable quantity is carried into the sewers. Where flushing is extensively used, the cleaning of catch basins becomes more necessary and must be included in the complete cleaning of the street. The character of the material removed by flushing is somewhat different from that removed by other methods as it contains a higher moisture content and a somewhat greater percentage of siliceous material.

Cleaning by hand and by machine brooms is somewhat similar so far as the effect on the character of the material and the effectiveness of cleaning is concerned. For proper cleaning by these methods, the surface should be sprinkled to avoid dust, and this wetting causes a large amount of the finely divided material to adhere to the surface of the streets, later to again appear as dust. Street cleanings from hand and machine operations are drier in appearance and contain less fine material and more manure than cleanings removed by flushers.

The value of street cleanings as a fertilizing material has been often claimed and has to some extent been studied by the U. S. Department of Agriculture. These studies have been limited, however, to requests for information from municipalities, etc., and cannot be considered as complete. In Ohio no utilization of the material is made.

In table No. 13 are given the average results of analyses of miscellaneous samples of street cleanings collected during the studies. The number of analyses is so limited that the results cannot be said to give true average results.

TABLE NO. 13.

SUMMARY OF ANALYSES OF STREET CLEANINGS.

	No. Anal.	Moisture.	Ash.	Comb. Matter.	Calor. Value.	Phos. Acid. (P_2O_5)	Kjeldahl Nitrogen.	Potash. (K_2O)
Cincinnati	6*	43.9	42.2	13.9	1445	.15	.23	.11
Cleveland	2†	29.0	48.8	22.2	2133	.18	.30	.14
Dayton	1‡	.....	82.1	17.9	1680	.22	.24	.43

*Material cleaned from streets by flushing machines. Principally granite pavements.

†Dry in appearance largely from white wing cans. Principally granite and brick pavements.

‡Sample dry and dusty. Taken from material removed from dry asphalt streets by hand broom and scraper.

QUANTITIES OF WASTE MATERIALS.

In learning the quantities of the various waste materials in the Ohio cities, data secured from the city departments having charge of the collection and removal of the wastes were obtained. At Cincinnati and at Cleveland it was possible to secure actual weight and volume of the garbage collected and a record of number of cubic yards of rubbish-ashes and street cleanings. At Columbus and Dayton only a record of the number of loads of garbage collected could be secured, and estimates of the weight were necessarily made upon the basis of data secured during the studies. At Dayton the records of rubbish-ashes collected consisted in the number of wagon loads, which were readily converted into the number of cubic yards. Quantities of street cleanings at Columbus were reported in cubic yards by the street cleaning department.

GARBAGE.

The total quantity of garbage produced in a municipality as represented by the amount collected is dependent upon a number of factors, the most important of which are the character of the population, the general tendency to furnish the material for collection, and the efficiency of the collection system itself. The character of the population has without doubt a marked effect upon the per capita quantity of garbage produced. The presence in a community of a large percentage of foreigners will result in a reduction in the average production of the material. This class of the population owing to its habits of living does

not produce an amount of garbage equal to that from the average American household. Furthermore, the foreign population as a rule is most difficult to educate in the necessity of providing proper receptacles to facilitate collection, and this also has a marked effect in reducing the per capita production from this class. The practice of burning garbage at the household in furnaces and stoves is also a custom among certain classes of persons but cannot be said to be typical of any of the cities of Ohio. The effect of private collection, by farmers and rendering companies, of household and hotel garbage is also a factor to be considered as causing an apparent reduction in the per capita production. Where there is an efficient collection system, the effect of private removal is generally not so marked. If, however, the municipal collection department is inadequate or improperly conducted, the unit production of garbage represented by the quantity collected will be reduced. In the city of Cleveland the large percentage of foreign population and the activity of private collecting companies are the principal factors which reduce the apparent per capita production. This result exists even with a well equipped and efficient municipal garbage department.

In table No. 14 are presented figures giving the total and unit quantities on a per capita basis of garbage collected in four cities in Ohio during the years 1907 to 1909. It will be seen that on the basis of volume the unit quantities at Columbus and Cincinnati are in excess of those of the other cities, while at Dayton the unit quantity on a weight basis is somewhat higher showing the effect of the excessive moisture content of the material in that city. It is interesting to note the low unit quantities at Cleveland, brought about no doubt by the influences before mentioned.

With an efficient collection system, the fluctuation in the quantity of waste material collected during the different seasons of the year should follow the production. From the average household the greatest production occurs during the summer months when vegetables and fruits constitute the principal diet. During that season of the year, therefore, it should be expected that the quantities collected be at their maximum. In a review of the monthly records of the garbage collection departments in the Ohio cities, it is found that this is true in each case.

In table No. 15 the per capita quantities of different waste materials for the four cities in Ohio are assembled. The figures in this table are calculated from data secured from the city departments. The figures representing the unit quantities of garbage collected are presented graphically in figure No. 6 and figure No. 7, which represent the cubic yards and pounds, respectively, per capita per month. These diagrams illustrate clearly the seasonal fluctuation in the unit production. Their general tendency is similar in that the maximum quantities occur during July, August, and September, and the minimum quantities during

the winter months. The Cleveland diagram departs somewhat from those for the other cities, exhibiting more regularity throughout the year with a less noticeable maximum during the summer months. This may be in part accountable by the fact that a large percentage of the population, notably the foreign portion, is no more productive of the garbage in the summer time than in other seasons of the year.

TABLE NO. 14.

TOTAL AND UNIT QUANTITIES OF GARBAGE COLLECTED ANNUALLY.

1907-1908 and 1909.

		Cincinnati.	Cleveland.	Columbus.	Dayton.
1907.	Population	352,000	507,000	.....	.....
	Tons	*a* 32,500	*a* 37,600	.....	.....
	Lbs. Per Capita	185	148	.....	.....
1908.	Population	356,000	525,000	170,000	110,360
	Cublic Yards	*b* 52,200	*c* 65,997	*b* 22,750	*b* 13,480
	Tons	*a* 32,240	*a* 41,334	*d* 13,500	*d* 9,941
	Cu. Yds. Per Capita	.1466	.1257	.1338	.1220
	Lbs. Per Capita	181	157.4	159	180
1909.	Population	360,000	543,000	176,000	113,500
	Cubic Yards	*b* 54,000	*c* 65,885	*b* 27,700	*b* 16,270
	Tons	*a* 34,760	*a* 44,600	*d* 16,500	*d* 12,000
	Cu. Yds. Per Capita	.1500	.1215	.1575	.1430
	Lbs. Per Capita	193.4	164.5	188	211

NOTES.

a Actual weight. Department records.
b Volume calculated from number of wagon loads.
c Volume calculated from number of car loads.
d Weight calculated from data on unit weight secured during studies

RUBBISH.

As is the case with the garbage, the quantity of rubbish and ashes produced in the city, as represented by the quantity collected is dependent upon the character of the community, the effect of private collection, and the efficiency of the municipal collection system. In those cities in which coal is used commonly as a fuel, the per capita quantity of ashes will be higher than in the so-called "gas city." On the other hand the combustible rubbish is likely to be reduced in the coal city as the opportunity for burning it in furnaces, stoves, and grates, is offered. In many cities, private enterprises are engaged in the collection of waste paper, resulting in a noticeable decrease in rubbish col-

TABLE NO. 15.

QUANTITY OF REFUSE COLLECTED — 1909.

Cubic Yards and Pounds Per Capita Per Month.

Locality.	Materials.	Jan.		Feb.		March.		April.		May.		June.		July.		August.		Sept.		Oct.		Nov.		Dec.		Total.	
		Cu. Yds.	Lbs.	Cu. Yds.	Lbs.	Cu. Yds.	Lbs.	Cu. Yds.	Lbs.	Cu. Yds.	Lbs.	Cu. Yds.	Lbs.	Cu. Yds.	Lbs.	Cu. Yds.	Lbs.	Cu. Yds.	Lbs.	Cu. Yds.	Lbs.	Cu. Yds.	Lbs.	Cu. Yds.	Lbs.	Cu. Yds.	Lbs.
Cincinnati, Population 360,000....	Garbage	.0084	10.3	.0081	10.1	.0080	9.8	.0106	13.4	.0101	13.2	.0131	17.6	.0179	24.0	.0166	23.4	.0196	26.6	.0130	15.9	.0117	14.6	.0124	14.5	.1500	193.4
	Rubbish, Ashes.....	.0648	60.5	.0597	55.7	.0610	59.6	.0582	39.7	.0487	33.3	.0430	29.3	.0400	27.3	.0373	25.3	.0380	25.9	.0443	30.1	.0510	34.5	.0694	64.8	.6184	486.0
	Street Cleanings....	.0191	.....	.0191	.....	.0349	.....	.0339	.....	.0316	.....	.0338	.....	.0314	.....	.0347	.....	.0337	.....	.0383	.....	.0321	.....	.0173	.....	.3600	.....
Cleveland, Population 543,000....	Garbage	.0099	13.0	.0083	11.0	.0088	11.8	.0083	10.9	.0087	11.7	.0100	14.6	.0106	14.6	.0124	16.3	.0124	17.8	.0111	16.0	.0103	14.9	.0107	11.9	.1215	164.5
	Rubbish, Ashes.....	.0427	35.6	.0298	24.8	.0430	35.9	.0357	29.9	.0325	27.2	.0312	26.0	.0269	22.4	.0286	23.9	.0238	19.8	.0276	23.0	.0312	26.0	.0204	17.1	.3734	311.6
	Street Cleanings....	.0102	.....	.0043	.....	.0250	.....	.0550	.....	.0288	.....	.0246	.....	.0315	.....	.0292	.....	.0291	.....	.0276	.....	.0294	.....	.0131	.....	.3078	.....
Columbus, population 176,000....	Garbage	.0099	9.4	.0089	8.6	.0099	9.4	.0126	15.4	.0110	13.4	.0113	13.8	.0153	19.2	.0165	20.6	.0219	27.4	.0136	17.0	.0119	15.0	.0147	18.4	.1575	187.8
	*Street Cleanings....	.0000	.....	.0042	.....	.0148	.....	.0276	.....	.0329	.....	.0370	.....	.0305	.....	.0406	.....	.0315	.....	.0386	.....	.0366	.....	.0041	.....	.3284	.....
Dayton, population 113,500.....	Garbage	.0094	13.9	.0098	14.4	.0107	15.8	.0101	14.9	.0103	15.2	.0117	17.3	.0146	21.6	.0154	22.7	.0158	23.3	.0127	18.9	.0116	17.1	.0109	16.1	.1490	211.0
	Rubbish, Ashes.....	.0358	39.1	.0364	39.8	.0447	48.7	.0424	46.2	.0400	43.6	.0391	42.6	.0425	46.3	.0420	45.8	.0407	44.4	.0423	46.2	.0406	44.3	.0416	45.4	.4881	532.4

*Quantities for 1910—Pop. 180,000.

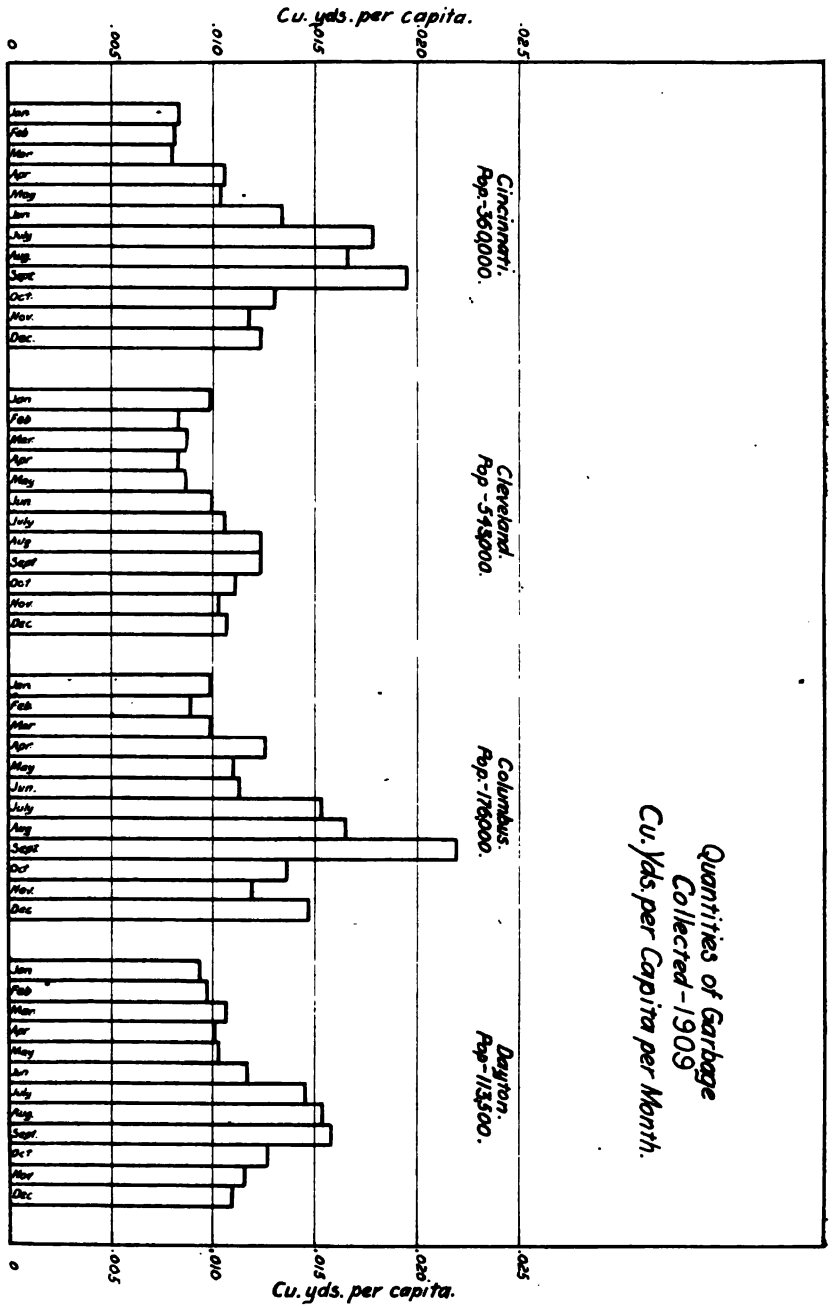

Quantities of Garbage Collected - 1909
Cu. Yds. per Capita per Month.
Cincinnati. Pop. - 364000.
Cleveland. Pop - 541000.
Columbus. Pop. - 176000.
Dayton. Pop - 113500.
Jan
Feb
Mar
Apr
May
Jun
July
Aug
Sept
Oct
Nov
Dec
0
.005
.010
.015
.020
.025
Cu. yds. per capita.

FIGURE NO. 6.

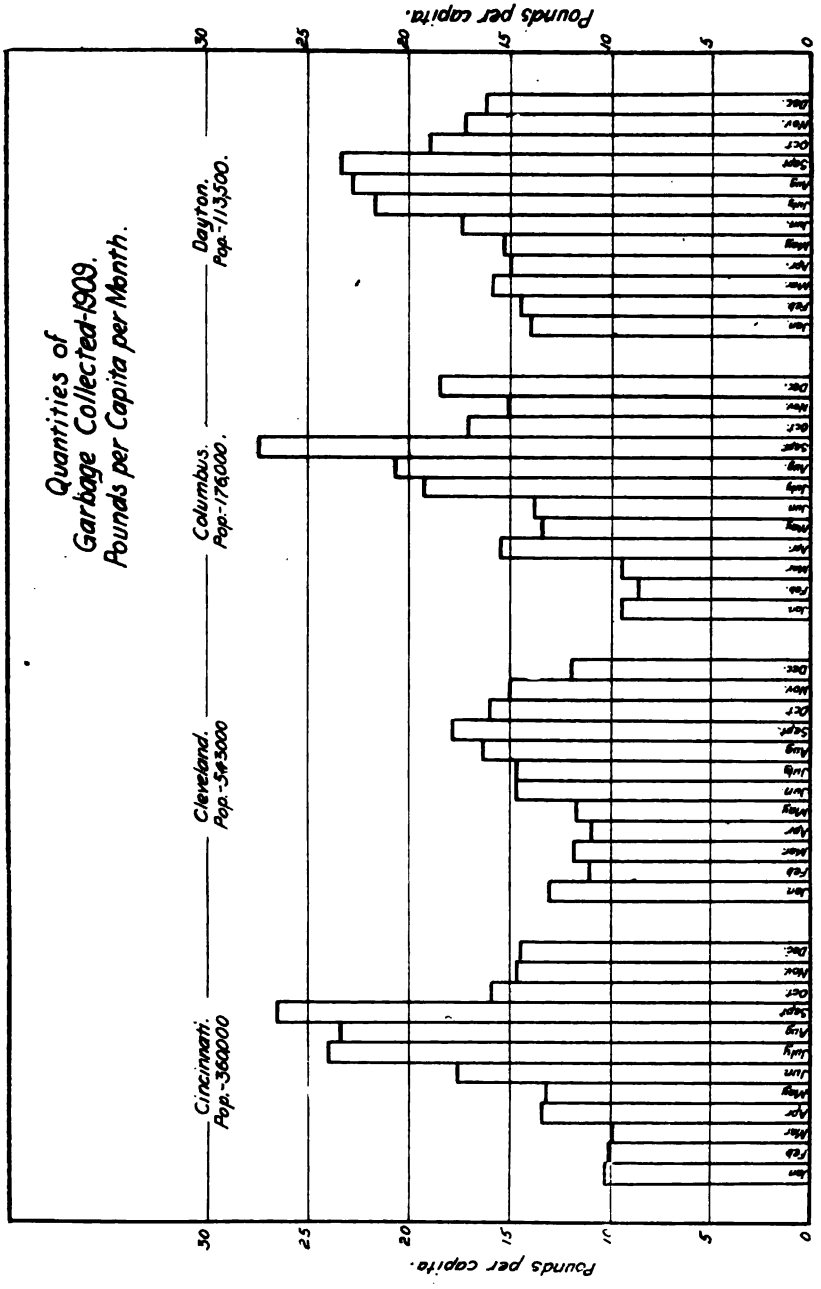

Quantities of
Garbage Collected-1909.
Pounds per Capita per Month.
Cincinnati.
Pop.-360000
Cleveland.
Pop.-543000
Columbus.
Pop.-176000.
Dayton.
Pop.-113500.
Pounds per capita.
30
25
20
15
10
5
0

FIGURE NO. 7.

lected. Of principal importance is the efficiency of the collection system. When frequent and regular collections are made, the people are educated to prepare the waste matrial to facilitate removal, and learn to appreciate the importance of its proper disposal.

In table No. 16 are figures representing unit quantities on a per capita basis of rubbish and ashes collected in three of the Ohio cities. In the city of Cincinnati the figures for three years, from 1907 to 1909, indicate a constancy in the quantity of the material removed. At Cleveland the records for the same years show an increase. At Cincinnati the rubbish department has been operating since 1865 and at the present time has reached almost its highest degree of development. At Cleveland, on the other hand, the department was organized in 1906 and is now undergoing progressive growth. At Dayton no records were kept prior to 1909.

TABLE NO. 16.

TOTAL AND UNIT QUANTITIES OF RUBBISH AND ASHES COLLECTED ANNUALLY, 1907-1909.

	Cincinnati.	Cleveland.	Dayton.
1907.			
Population	352,000	507,000	
Cublic yards	235,370	167,084	
Tons*	92,618	69,674	No records.
Cubic yards per capita	.6687	.3295	
Pounds per capita	526	265	
1908.			
Population	356,000	525,000	
Cubic yards	229,818	200,656	
Tons*	90,830	83,650	No records.
Cubic yards per capita	.6455	.3821	
Pounds per capita	510	319	
1909.			
Population	360,000	543,000	113,500
Cubic yards	222,634	202,752	55,414
Tons	87,611	84,550	30,200
Cubic yards per capita	.6183	.3734	.4881
Pounds per capita	486	311.6	532.4

*Weight in tons estimated from data secured during studies as follows:
Cincinnati, 787 lbs. per cubic yard; April to Nov., 682 pounds; January, February, March and December 935 pounds.
Cleveland, 834 lbs. per cubic yard.
Dayton, 1.090 lbs. per cubic yard.

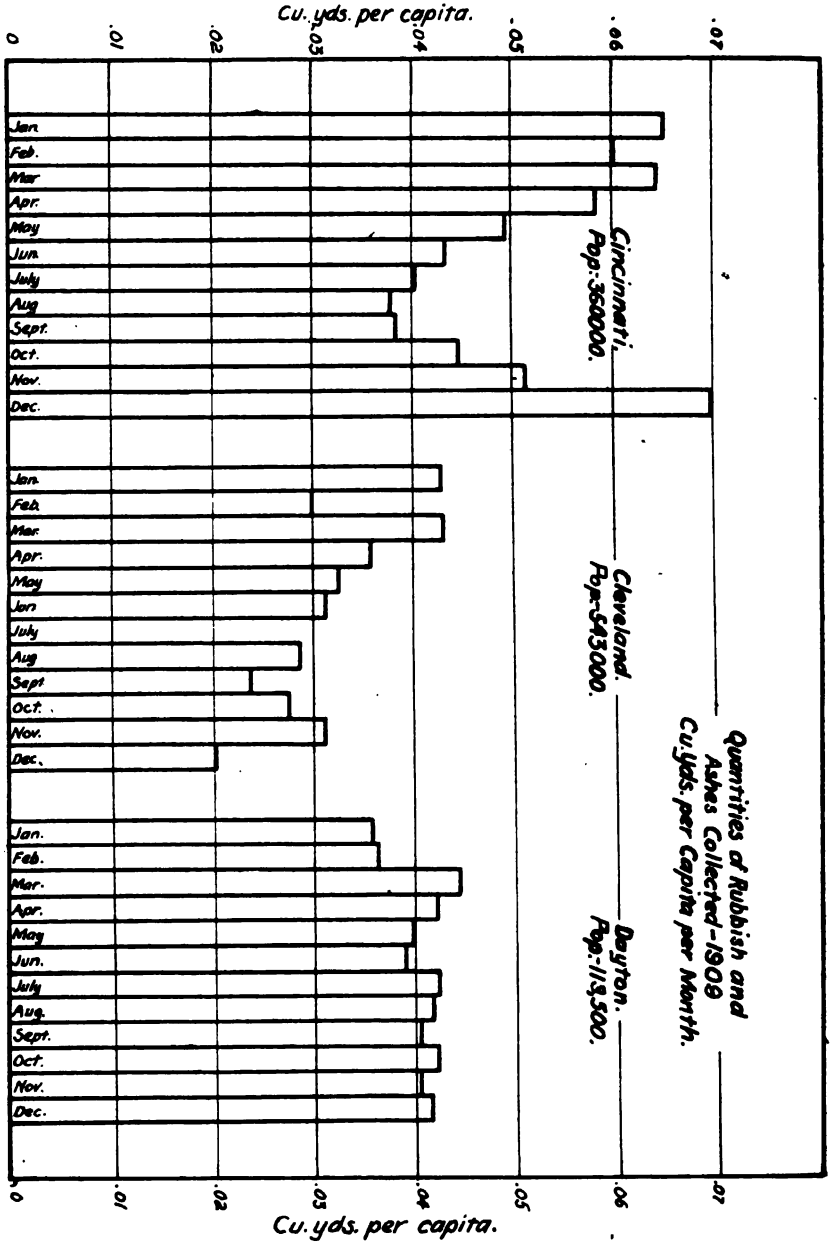

Cu. yds. per capita.
0
.01
.02
.03
.04
.05
.06
.07
Jan.
Feb.
Mar.
Apr.
May
Jun.
July
Aug.
Sept.
Oct.
Nov.
Dec.
Cincinnati.
Pop: 360000.
Jan.
Feb.
Mar.
Apr.
May
Jun
July
Aug
Sept
Oct.
Nov.
Dec.
Cleveland.
Pop:-543000.
Jan.
Feb.
Mar.
Apr.
May
Jun.
July
Aug.
Sept.
Oct.
Nov.
Dec.
Dayton.
Pop:-113,500.
Quantities of Rubbish and Ashes Collected-1909
Cu.yds. per Capita per Month.
Cu. yds. per capita.

FIGURE No. 8.

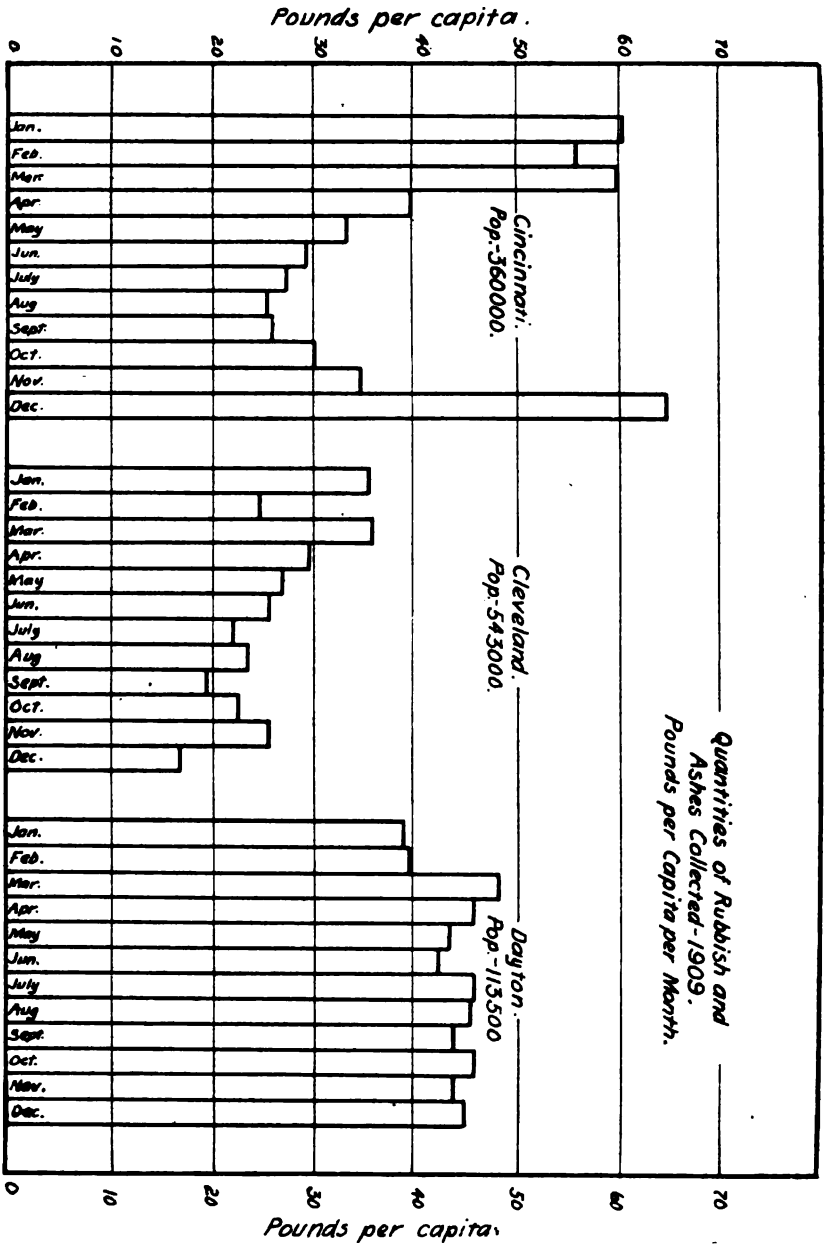

Pounds per capita.
0
10
20
30
40
50
60
70
Jan.
Feb.
Mar.
Apr.
May
Jun.
July
Aug
Sept.
Oct.
Nov.
Dec.
Cincinnati.
Pop.-360000.
Jan.
Feb.
Mar.
Apr.
May
Jun.
July
Aug
Sept.
Oct.
Nov.
Dec.
Cleveland.
Pop.-543000.
Jan.
Feb.
Mar.
Apr.
May
Jun.
July
Aug
Sept.
Oct.
Nov.
Dec.
Dayton.
Pop.-113500
Quantities of Rubbish and Ashes Collected-1909.
Pounds per Capita per Month.
0
10
20
30
40
50
60
70
Pounds per capita.

FIGURE No. 9.

The fluctuation in the quantity of rubbish collected during the different months of the year is shown in table No. 15 given on a foregoing page. The figures in this table are presented graphically in figures Nos. 8 and 9. The fluctuation at Cincinnati shows clearly the seasonal effect on the unit production. During the winter months the general use of coal causes a marked increase in the quantity produced. On the other hand, the minimum quantities occur during the summer months when the corresponding use of fuel is low. The diagrams for Cleveland and Dayton do not illustrate a marked seasonal fluctuation and more regularity throughout the year is apparent. This in the case of Cleveland is probably due to the general use of gas as a fuel, and at Dayton to the fact that the development of the collection system is somewhat less complete than in the other cities.

STREET CLEANINGS.

The quantities of street cleanings removed are dependent upon the kind and character of paving, methods of cleaning, and the efficiency of the department. The quantity of material required to be removed is smaller where the streets are completely paved and kept in good repair. Cleaning of streets by flushing reduces the quantity to be removed for the reason that a large amount of material is carried into the sewers through the gutters. The enforcement of local regulations prohibiting the littering of streets with rubbish, droppings from wagons and carts, and waste materials from construction, also has a marked effect in reducing the quantity of street cleanings to be removed. These factors could not, however, be studied during this investigation without involving unreasonable time and expense.

In table No. 17 are presented total and unit quantities of street and catch basin cleanings for three of the cities of Ohio. In connection with a study of this table it may be of interest to refer to table No. 2 giving the methods of cleaning used for these cities.

The unit quantities of street cleanings given in table No. 15 are presented graphically in figure No. 10. It will be seen that in each of the cities fairly uniform removal takes place during the greater portion of the year, the minimum activity occurring during the winter months when weather conditions interfere with the work. It is of interest to note the "clean up" occurring in April, 1909, in Cleveland, and in March, 1910, in Columbus, following neglect of the streets due to weather conditions during the winter months.

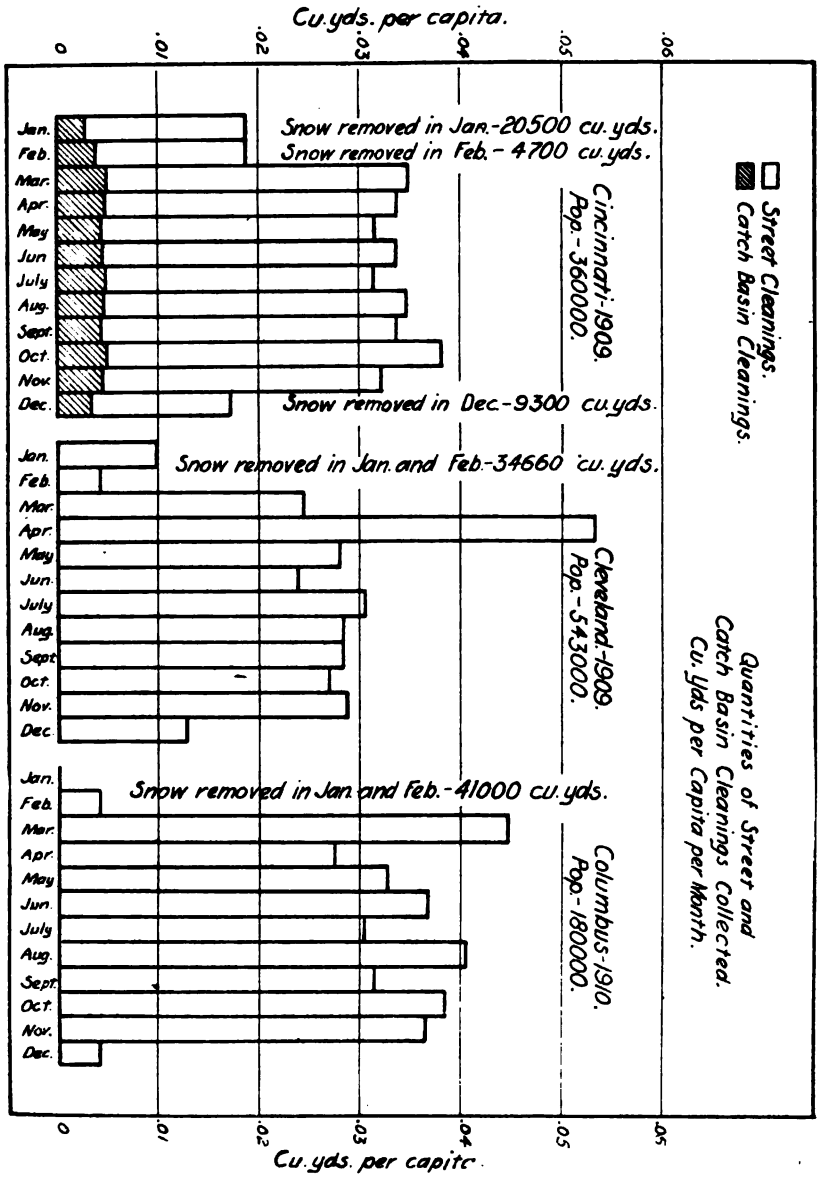

Cu. yds. per capita.
0
.01
.02
.03
.04
.05
.06
Quantities of Street and Catch Basin Cleanings Collected. Cu. Yds per Capita per Month.
Street Cleanings.
Catch Basin Cleanings.
Cincinnati-1909. Pop.-360000.
Snow removed in Jan.-20500 cu. yds.
Snow removed in Feb.-4700 cu. yds.
Snow removed in Dec.-9300 cu. yds.
Cleveland-1909. Pop.-543000.
Snow removed in Jan. and Feb.-34660 cu. yds.
Columbus-1910. Pop.-180000.
Snow removed in Jan. and Feb.-41000 cu. yds.
Jan.
Feb.
Mar.
Apr.
May
Jun.
July
Aug.
Sept.
Oct.
Nov.
Dec.
Cu. yds. per capita.

FIGURE No. 10.

TABLE NO. 17.

TOTAL UNIT QUANTITIES OF STREET AND CATCH BASIN CLEANINGS.

	Cincinnati.	Cleveland.	Columbus.
Year	1907	1907	
Population	352,000	507,000	
Squares cleaned (10,000 sq. ft.)	162,761	399,574	
Street cleanings, cubic yards	90,600	170,000	No records.
Cubic yards per capita	.2574	.3353	
Snow removed, cubic yards	3401	.....	
	1908	1908	
Population	356,000	525,000	
Squares cleaned (10,000 sq. ft.)	270,916	405,381	No records.
Street cleanings, cubic yards	148,870	177,191	
Cubic yards per capita	.4183	.3375	
Snow removed, cubic yards	1,550	.....	
Catch basin cleanings, cubic yards	15,469	.....	
	1909	1909	1910
Population	360,000	543,000	180,000
Squares cleaned (10,000 sq. ft.)	321,583	373,880	190,761
Street cleanings, cubic yards	129,360	167,000	59,119
Cubic yards per capita	.3593	.3078	.3284
Snow removed	32,770	34,660	41,000
Catch basin cleanings, cubic yards	18,772	.....	.....

METHODS OF FINAL DISPOSAL.

Various methods of disposal of the wastes of the municipalities of Ohio are practiced. Those cities in which studies were made had developed the greatest perfection in this work and in each city there was maintained a suitable plant for the disposal of garbage and proper facilities for the disposal of other wastes. The following outline will give in brief form a statement of the methods employed in the cities studied.

METHODS OF DISPOSAL OF CITY WASTES IN OHIO CITIES 1910.

	Garbage.	Rubbish and Ashes, Street and Catch Basin Cleanings.	Dead Animals.	Manure.	Night-Soil.
Cincinnati	Reduction	Dumping	Reduction	Removed from city privately by farmers. Used as fertilizing material.	Sewers.
Cleveland	Reduction	Dumping	Reduction		Sewers.
Columbus	Reduction	Dumping	Reduction		Sewers.
Dayton	Reduction	Dumping	Reduction		Burying.
Canton	Incineration	Dumping			Burying.
Mansfield	Incineration	Dumping	Reduction, Incineration or Burial.		Burying.
Marion	Incineration	Dumping			Incineration and burying.
Steubenville	Incineration	Dumping			Burying.
Zanesville	Incineration	Dumping			Burying.

GARBAGE.

During the studies, the opportunity was had for studying three methods of disposal of garbage, namely, disposal by burying, by reduction, and by burning. Disposal by burying was practiced in Columbus during the period of the investigation, this method being supplanted by reduction in July, 1910, after the field work had been completed. In Cleveland, Cincinnati, and Dayton, the reduction process has been used for a number of years, while in each of the smaller cities the garbage is burned in municipally owned crematories.

Disposal by Burying. This method of disposal may be considered as the primitive one in this state as has been the case elsewhere. It was found to be in use in but one of the cities studied, namely, Columbus, but in a great number of the municipalities throughout the state it is the customary method of disposal. This is especially true of the smaller communities. At Columbus this method was employed as a temporary expedient during the time elapsing between the expiration of a contract with a private company and the construction of a municipal reduction plant.

To provide a place for the disposal of garbage, the city of Columbus purchased a farm of 70 acres suitably located southwest of the city and employed it continuously from 1906 to 1910 as a burial ground for all garbage, night soil, and dead animals from the city. The material was placed in pits dug to a depth of about two feet, with an average width of seven feet and of indefinite length, and covered with a layer of from

one to two feet of loose soil. Approximately fifteen acres of land were used in this way each year, and observation pits indicated that two and one-half years after burial, the garbage had been converted to a stable condition and the land was ready to be used again.

Disposal by burying when properly conducted and when the point of disposal is suitably located, gives no cause for objections from a sanitary standpoint. At Columbus the method was entirely without objection as the burial ground was located at a distance of at least one thousand feet from any dwelling and extreme care was taken to avoid the production of odors by prompt covering of the material after dumping. The principal objection that has been raised to this method of disposal, especially in large cities such as Columbus, has been the extremely long haul which is required in conveying the garbage to the burial ground. In small communities where this feature does not create an objection, the method of disposal is entirely satisfactory.

Disposal by Reduction. In Cleveland, Cincinnati, Dayton, and recently at Columbus, garbage is disposed of by the reduction process. At Cleveland and Columbus the plants are municipally owned and operated, while at Cincinnati and Dayton they are privately owned and operated under contract with the municipality. At Toledo, the other large city of the state, there is at present being constructed by a private company a reduction plant to treat the garbage of the city. When this shall have been done, all of the cities in the state with populations of 100,000 and upwards, will be equipped with reduction plants for the disposal of garbage.

The reduction process has been developed in this country during the past fifteen years. Until recently the process has been entirely in the hands of utilization companies which secured contracts with municipalities and in many cases received large returns from their investments. In recent years, however, municipalities have turned their attention toward municipal ownership of garbage reduction plants, and the consequent attention which the engineering profession is giving to this problem is accomplishing much in the improvement of the process. In 1906 there were not more than twenty reduction plants in the United States, all operated by private companies. The development in recent years, however, has materially increased the number, and the reduction method is almost universally used in the large cities of the country.

Garbage reduction is a process by which the raw material is treated to separate the solid and liquid portions and recover the grease contained from one or both. The solid portion, known as tankage, and the grease have a market value and are sold, while the liquid portion is principally water and is a waste from the process. It is objectionable if it carries with it impurities of a putrescible nature.

The development of reduction processes is an outgrowth of the methods which have been used for many years in the recovery of sale-

Columbus — Burial of garbage on English farm.

able products from packing house wastes. There are several patented processes, each of which is more or less successful in accomplishing a means of disposal. The relative merits of the different methods are much discussed and are not entirely decided. Each process has its distinguishing features, but all are somewhat similar in the essential parts of the treatment. The four plants in Ohio differ from one another in the details of the methods used, but all have common characteristics in their main features.

The Dayton plant is the simplest in its operation of any of the plants of Ohio. Here the so-called Edson process is used. All of the raw material, including the water contained, is placed in digesters and cooked with steam for several hours, after which the material is transferred to driers. After drying, the tankage is percolated with naphtha, by means of which the grease is removed and from which it is subsequently recovered. The only waste from the process consists of the tailings from the tankage screens. This material is of an unobjectionable nature and is disposed of without nuisance by dumping.

The Cleveland plant is a modification of the Edson process which was employed during the first few years of its operation. At this plant the raw garbage is partly drained before its treatment. The liquor drained off is wasted. The material is then cooked as at Dayton, but before it is transferred to the driers the liquor contained, which also carries a large amount of the grease, is forced from the mass by steam pressure and conducted into open tanks. Here the grease collects at the surface and is drawn off, the liquor remaining at the bottom being allowed to flow to waste. The tankage is conducted from the digesters to driers, and after drying, the grease is removed from it by percolation with naphtha. The tankage is then screened and is ready for shipment.

The wastes from the Cleveland plant, aside from the tailings from the screens, consist of the liquors from the raw material and from the grease separating tanks. These wastes are permitted to run directly into a small stream near the plant and at times create an objectionable nuisance.

At the Cincinnati plant an improvement upon the old Detroit liquid-separating process is employed. Here the raw garbage is partially drained before treatment as at Cleveland. The liquor undergoes sedimentation before being wasted, and a small quantity of grease is recovered by this means. The drained garbage is cooked in a manner common in reduction plants, and is then transferred to hydraulic presses and the greater portion of the liquor and grease contained is forced from the mass. The liquor containing the grease is conducted to open separating tanks, the grease being removed from the surface and the liquor being wasted into a sewer. The pressed tankage is dried, screened, and stored. Until recently the tankage has been shipped with no further

treatment, but during the summer of 1910 there was added a plant for the recovery of grease from this tankage by percolation with naphtha.

The wastes from the Cincinnati plant consist of the mixed liquors from the raw garbage and from the presses and are discharged into the Ohio River. So great a dilution is afforded that no nuisance results.

The recently completed plant at Columbus employs essentially the same processes that are used at Cincinnati. The Columbus plant, however, has been equipped with the most improved types of the various machines and in appearance differs greatly from the Cincinnati plant. At Columbus, moreover, no liquid waste is produced. At this plant the raw material is drained, the liquor being conducted to a well which also receives the liquor from the presses. The drained garbage is cooked, pressed by means of roller presses, and partially dried. At this point there is mixed with it a so-called "stick" which is the liquor from the grease separating tanks converted to a syrup by a triple-effect evaporator. The mixed tankage and "stick" is then completely dried, screened, and stored for shipment. There is now being erected a percolation plant for the further treatment of the tankage.

It will be seen that the wastes from the Columbus plant are only the tailings from screens and are not of an objectionable nature.

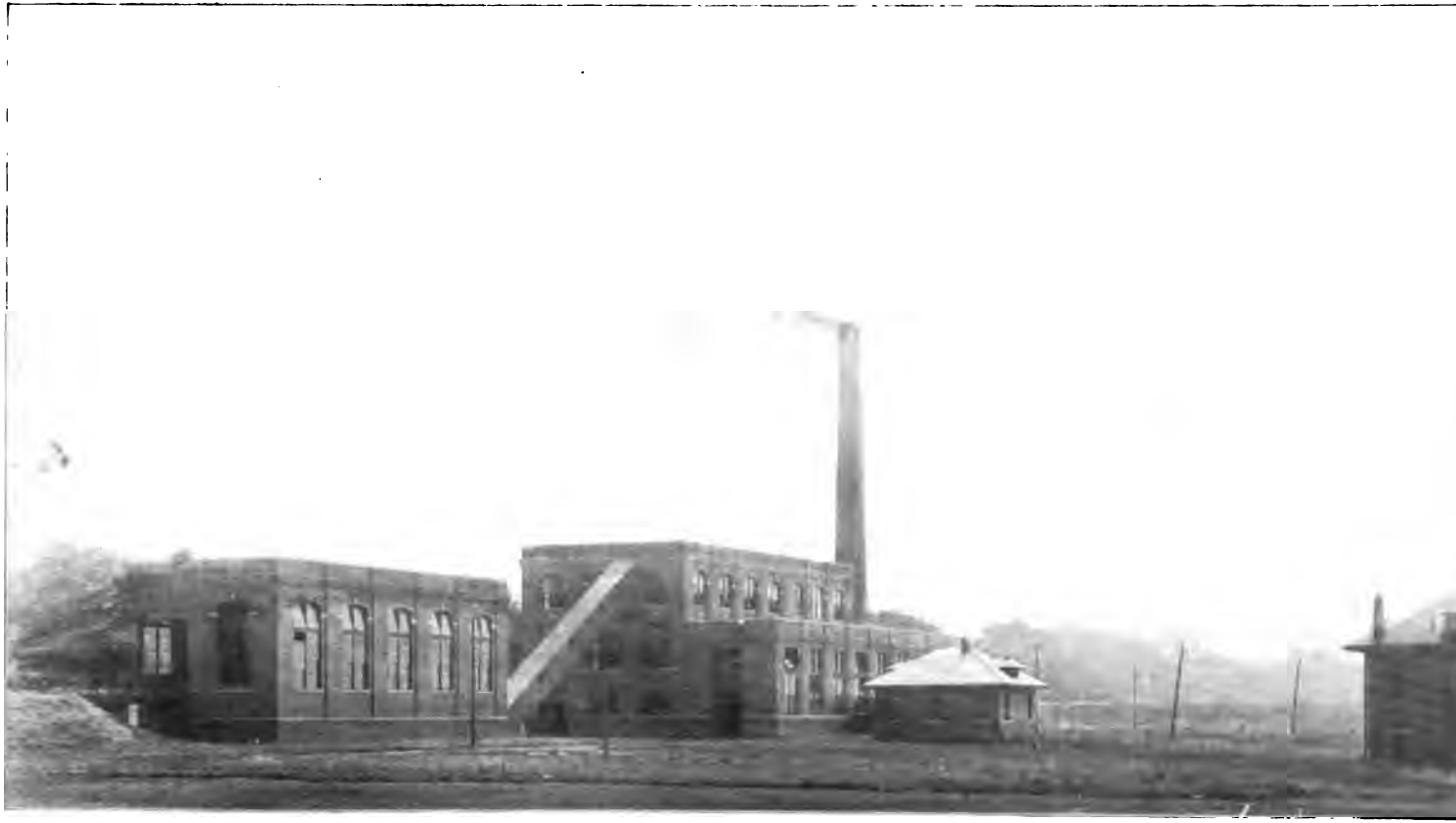
The reduction process or any modification of it will produce odors. The odors produced are objectionable to some persons but are not more so than those produced by various industries engaged in manufacturing processes similar to garbage reduction. Such plants are, however, considered as legitimate and are not subject to the objection which is raised against a garbage plant. With proper design and careful operation, reduction plants may be conducted without producing a serious nuisance. The private plants which have been built in this country and which are made the basis for objection to the process, are as a rule built without regard for the prevention of odors and generally create a serious nuisance. The most recent development in this country is shown in the plant at Columbus, and it is there demonstrated that the reduction process may be carried on without the production of very serious odors. When a liquid waste is produced and discharged into a stream, the plant may create a decided nuisance. With proper design, however, it is unnecessary to discharge an objectionable waste from the plant.

Disposal by Burning. In Ohio the disposal of garbage by burning has been confined almost entirely to cities ranging in population from 20,000 to 80,000. This method is used at Canton, Mansfield, Marion, Steubenville, Zanesville, East Liverpool, and Youngstown, and was studied in each of these cities excepting the last two mentioned.

The burning or incineration of refuse as a means of disposal was developed abroad. The principal work has been done in England and in Germany since 1875, and at the present time it is the accepted method in those countries. In the United States it has not as yet been universally adopted, and its success has been confined to the very large and to

Digesters at Columbus garbage reduction plant.

Dayton — General view of plant of Dayton Reduction Company.



Columbus — General view of municipal reduction plant.

Cleveland — General view of municipal reduction plant.

the rather small cities of the country. It is applicable in the very large cities only when the collection systems are suitable to provide for the burning of mixed refuse.

Disposal by burning is applicable for nearly all classes of refuse, and all city wastes except ashes and street cleanings are suitably disposed of by this means. In small cities it is the custom to employ incineration for the disposal of garbage alone, the other classes of wastes being dumped or buried. This condition was found in each of the Ohio cities maintaining crematories. The practice is due largely to the condition of the collection systems as in the smaller cities garbage constitutes the only waste which is efficiently removed. Briefly, the incineration of garbage is practiced by placing the raw material in a suitably constructed furnace or cell, which by the use of coal or other fuel is raised to a sufficiently high temperature to accomplish the destruction of the garbage. Incineration is most successfully practiced where combined collection of wastes is provided or complete separate collection, all combustible wastes being delivered at the plant. Where garbage alone is burned, large quantities of fuel and efficient attention by an operator are required in order that high temperatures may be produced and objectionable odors avoided. In small cities, efficient attention is often lacking, and objectionable odors are created by the process and carried for long distances. Suitable location of the plants will, however, avoid complaint.

All of the garbage crematories in Ohio are patented types having certain distinctive features in design which differentiate them one from the other. They are common in one respect, however, in that the design provides for the burning of garbage alone, and to this end each type is designed for the use of fuel. Under ideal conditions it is likely that any of the furnaces in the state will give satisfactory results in the destruction of garbage. The proper operation of the plants, however, involves considerable study and attention on the part of the operator, and where this is not given, the furnaces do not produce entirely satisfactory results. The principal objection to the garbage crematory for the small city consists in the nuisance caused by the production of offensive odors in the burning process. These odors are avoided only under theoretical or ideal conditions when a high temperature is constantly maintained, and the failure even for a short period to maintain this temperature will immediately result in foul odors being emitted from the stack. The extent to which these odors are objectionable depend upon the location of the plant, and if this has been properly selected at a sufficient distance from the built up portion of the community, no complaint is likely to be made.

The incineration process is entirely satisfactory from a sanitary standpoint, and no liquid or putrescible solid waste is produced. Its limitations for the burning of garbage alone are owing to the high cost of the process, and on an economic basis it is less desirable for the city

of 100,000 population than a suitable reduction process. Where mixed collections are burned, the relative desirability of the incineration and reduction processes is not decided, and in some cases one and in some the other is most applicable.

RUBBISH, ASHES, STREET AND CATCH BASIN CLEANINGS.

In Ohio but one method of disposal of rubbish, ashes, and street and catch basin cleanings is practiced, namely, dumping on land. In those cities in which the collection departments are well organized the disposal of the material is systematic. In six of the cities of the state, which have no organized collection systems for rubbish and ashes, the dumping of the material is promiscuous and has led to unsatisfactory conditions. In Cincinnati, Cleveland, and Dayton, where municipal collections are made, all of the waste materials are dumped on low land within the corporate limits, which would otherwise be of no value. In this way it has been possible to create park lands, furnish means for continuing streets across deep depressions, and generally improve the appearance of the surroundings. Such land is, however, unfit for building purposes for a number of years after its making.

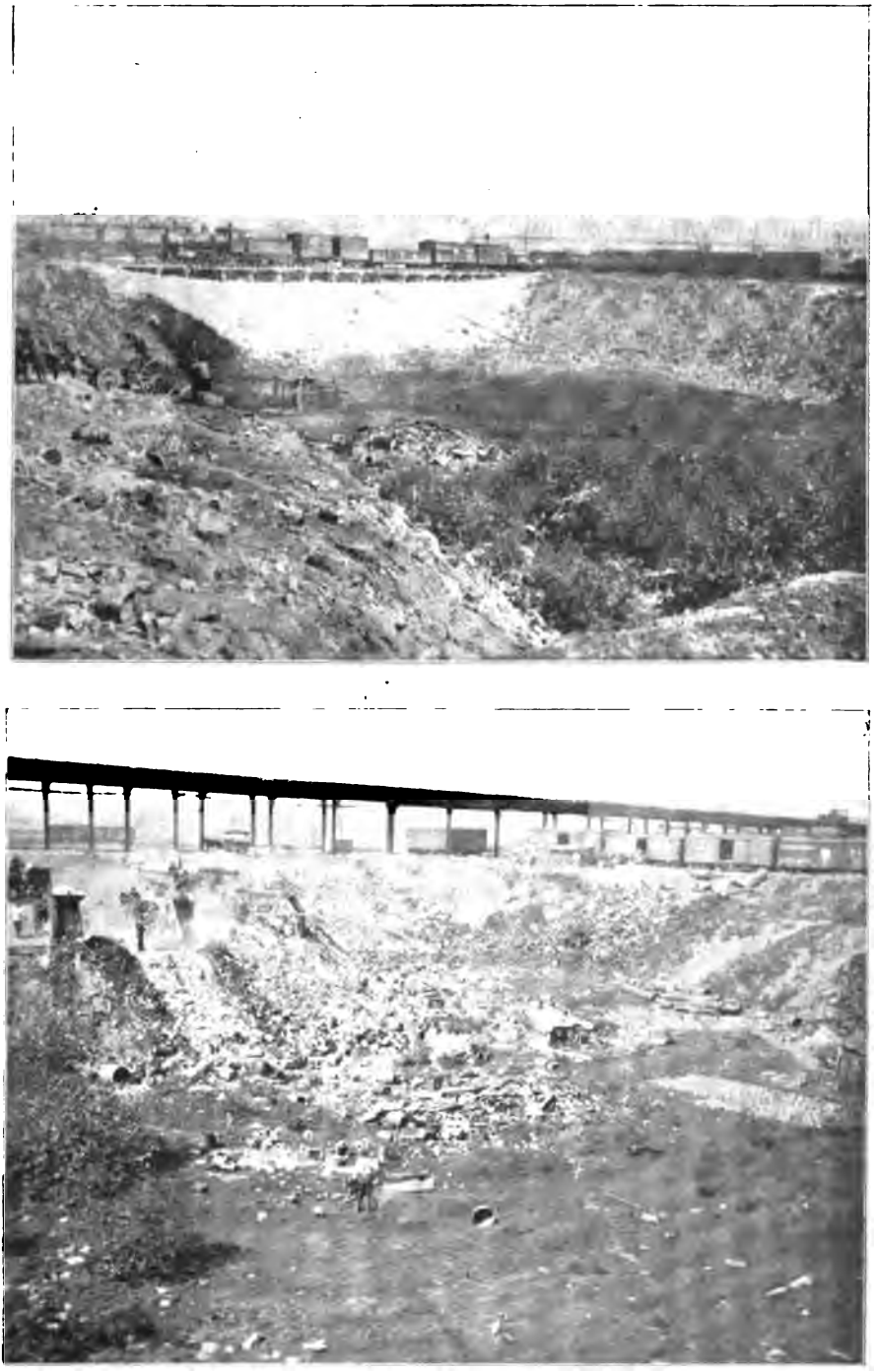
In maintaining the dumps in the various cities, it was found to be the common practice to place the rubbish and light material near the bottom of the fill and to surface the dump to a depth of several feet with ashes, street cleanings, and cellar excavations. When maintained in this condition, the completed portions of the dumps present a neat and finished appearance.

The principal objections to rubbish dumps lie in the characteristic odors which they create and in unsightly conditions in the vicinity caused by the transportation by wind of the waste paper, dust, etc. The odors from dumps are moreover often emphasized by the presence of fires within the material. The smoke nuisance attending this, as well as the serious odor produced, is very unpleasant if not unhealthful for persons residing in the vicinity, and in a number of cases has brought forth serious complaints. The appearance and condition of dumps are, however, largely dependent upon the experience and attention of the man in charge. By judicious placing of the material, it is possible even with a large percentage of loose rubbish to keep the dump well covered and prevent nuisance.

The conditions in Ohio in the disposal of rubbish, ashes, and street and catch basin cleanings, by dumping, seem to indicate that some improvement could be made in this practice. The dumping of ashes, and street and catch basin cleanings is attended by no nuisance, and moreover produces a very satisfactorily filled ground. The presence of loose and combustible rubbish, often mixed with garbage, however, introduces means for the production of decided nuisances either resulting in fires or decomposition of the putrescible matter contained. From a sanitary standpoint as well as from an economic standpoint, it appears that the

Canton — Garbage crematory.

Steubenville — Garbage crematory.



Cincinnati — Views of one of the principal rubbish dumps of the Mill Creek Valley.

Cleveland — Partial view of typical rubbish dump.

Cincinnati — Partial view of one of the smaller rubbish dumps in a residential district.

Face of a typical rubbish dump showing class of material at foot of slope.

rubbish should be collected and disposed of by other means than by dumping.

MANURE AND NIGHT SOIL.

These classes of wastes are in no instance in Ohio collected at municipal expense. The disposal of manure is largely dependent upon its removal by farmers and is in no case organized. In the larger cities of the state the disposal of night soil is under municipal supervision, and at Cleveland a municipal night soil department is maintained. In the smaller cities, however, its disposal is unsystematic, and the material is in most cases buried at some point outside the corporation limits selected by the contractor. At Cincinnati the material is discharged into the sewers; at Cleveland until recently it has been dumped into Lake Erie, an employee of the the service department being delegated to select the time and location for dumping, in order to avoid the possibility of contamination of the water supply. At Columbus and at Dayton the material has in the past been disposed of by burial, but recent improvements at Columbus provide for its discharge into the intercepting sewer. At Marion, one of the smaller cities of the state, night soil has been disposed of for a number of years by cremation with the garbage. This practice was very expensive and recently has been abandoned and the material disposed of by burial.

DEAD ANIMALS.

The disposal of the carcasses of animals has not been placed on an organized basis in most of the cities of the state. At Cincinnati the contract with the Cincinnati Reduction Company provides for the removal of all dead animals by that company, and this places the work on a systematic basis and provides for its proper accomplishment. Where muncipalities have attempted to carry on the work to the exclusion of private enterprises, much trouble has been experienced owing to the competition created. At present the cities of Cleveland and Columbus have provided their garbage departments with suitable wagons for the removal of dead animals and are ready to care for this work. However, in each city privately owned rendering companies are engaged in the same work and attend to the removal of the greater number of the larger animals. In the smaller cities of the state, dead animals are removed by private collectors and are principally disposed of by rendering. In a few of the cities, the animals are delivered at the garbage crematory and burned.

The collection and disposal of the smaller animals, dogs, cats, etc., is usually connected with the work of the garbage department where such is maintained. In the absence of this department, the collection of the smaller animals is generally neglected.

COST DATA.

The cost of the collection and disposal of city wastes is dependent upon a number of conditions. The completeness with which the work

is done and the working efficiency of the departments are perhaps the most important factors affecting the total cost of the work. In the removal of the various classes of waste, a condition of great importance affecting the cost is the length of haul to the point of final disposal. The cost of disposal of wastes is entirely dependent upon the method employed and the efficiency with which it is carried on.

In securing cost data from the city departments throughout the state difficulty was experienced in obtaining complete and accurate costs presented in proper form. It was possible, however, in the greater number of cases to secure department reports and these were used as a basis for the figures presented.

GARBAGE.

The costs of garbage collection were only incompletely obtained owing to the difficulty of securing separate records of collection and disposal. At Cleveland accurate records are kept giving the cost of each branch of the work. In table No. 18 are presented the costs for several years at Cleveland, Dayton, and Zanesville. It will be noted that the cost of collection at Cleveland has undergone a gradual increase brought about largely by increase in efficiency and completeness of collection.

TABLE NO. 18.

COST OF GARBAGE COLLECTION.

City.	Year.	Total Cost.	Cost per Capita.	Cost per Ton.
Cleveland	1905	$65,989	$0.14	$2.17
	1906	79,233	.16	2.27
	1907	98,278	.20	2.62
	1908	107,020	.197	2.40
	1909	124,701	.222	2.79
Dayton	1907	18,000	.167	....
	1908	21,000	.196	2.11
Zanesville	1908	2,600	.096	....
	1909	2,466	.090	....
	1910	2,552	.091	2.13

The cost of disposal is dependent upon the method employed and is affected largely by the efficiency obtained. At Cincinnati the cost of collection and disposal are combined and represented by the amount paid to the Cincinati Reduction Company. At Dayton the disposal cost to the city is nothing owing to the fact that a private company receives the material without a bonus. At Cleveland the operation of the reduction works returns a profit to the city. In table No. 19 are presented records for a number of years, which indicate the profit at the Cleveland municipal reduction works. It will be seen that increased efficiency in the operation of the plant has resulted in a marked increase in the profits.

TABLE NO. 19.

NET PROFIT OF GARBAGE REDUCTION AT CLEVELAND.

Year.	Total Net Profit.	Profit per Capita.	Profit per Ton Garbage.
1905	$5,121	$0.011	$0.167
1906	19,613	0.041	0.562
1907	33,885	0.067	0.902
1908	55,874	0.103	1.25
1909	85,715	0.153	1.92

In table No. 20 are given records of the cost of disposal of garbage by incineration in several cities in Ohio. The fluctuations which appear in this table are due largely to irregular methods of operation of the crematories. It is important to note also that the costs at Marion and Steubenville are reduced by revenues resulting from fees charged for burning certain classes of material.

TABLE NO. 20.

COST OF DISPOSAL OF GARBAGE BY INCINERATION.

City.	Year.	Total Net Cost.	Cost per Capita.	Cost per Ton.	Fuel Cost per Capita.
Canton	1906	$1,508	$0.036	$1.97	$0.75
	1907	3,671	0.083	4.30	0.83
	1908	2,352	0.051	2.50	1.15
	1909	1,999	0.042	1.78	0.97
Marion	1906	1,729	0.110	2.66	1.81
	1907	1,573	0.096	2.00	1.11
	1908	1,809	0.107	2.59	1.10
Steubenville	1908	1,651	0.074	1.84	0.47
	1909	1,330	0.062	1.11	0.28
	1910	2,142	0.096	1.00	0.19
Zanesville	1908	1,450	0.068	.....	....
	1909	1,941	0.117	.....	....
	1910	1,676	0.110	2.58	0.63

NOTE.

Character of Refuse Destroyed.
Canton — Garbage, 100%.
Marion — Garbage, 72 %; night soil, 22.2%; dead animals, 5.4%.
Steubenville — Garbage, 90%; mixed refuse and dead animals, 10%.
Zanesville — Garbage, 75%; mixed refuse, 25%.

In table No. 21 are shown the combined costs of garbage collection and disposal in several cities of Ohio. At Cleveland the total net costs are represented by the difference between the costs of collection and the profits from disposal. At Cincinnati the costs are represented by the contract prices paid by the city. At Columbus the figures include the collection and disposal of the material by burial previous to the introduction of the reduction works. At Dayton the figures include collection only, as the disposal of the material is without cost to the city. At Zanesville the costs of collection and disposal by burning are included.

It is interesting to note the regular and marked decrease in cost at Cleveland and to compare the costs with those at Cincinnati where the city carries on the work through a contractor. The low costs at Cleveland are entirely due to the efficient manner in which the reduction works are operated.

TABLE NO. 21.

COST OF GARBAGE COLLECTION AND DISPOSAL.

City.	Year.	Total Net Cost.	Cost per Capita.	Cost per Ton.
Cleveland	1905	$60,868	$0.13	$2.00
	1906	59,620	0.12	1.71
	1907	63,393	0.125	1.68
	1908	51,146	0.094	1.14
	1909	38,986	0.069	0.87
Cincinnati	1907	86,000	0.244	2.646
	1908	88,000	0.247	2.724
	1909	90,000	0.250	2.590
Columbus	1908	36,000	0.212	2.667
	1909	40,706	0.231	2.457
Dayton	1907	18,000	0.167	....
	1908	21,000	0.190	2.11
Zanesville	1908	4,450	0.164	....
	1909	5,695	0.207	....
	1910	5,650	0.201	4.71

RUBBISH AND ASHES.

The cost data for collection and disposal of rubbish and ashes are confined to records of three cities. The costs are almost entirely for collection, and the disposal cost includes only labor at dumps. In table No. 22 are given net and unit costs for three Ohio cities. The net costs take into account the revenues of the departments from sale of rubbish, filling of land, etc., the items of which are given in the detailed portions of this report. It will be noted that the costs at Cincinnati and at Cleveland compare very closely. The cost at Dayton is lower than in either

of the larger cities, the result no doubt of a much shorter average length of haul to the dumps.

The costs at Cincinnati include labor, stable maintenance and repairs, but do not include new equipment and overhead expense. The figures for Cleveland include labor, team hire, and repairs, but do not include new equipment and overhead expense.

TABLE NO. 22.

COST OF RUBBISH AND ASHES COLLECTION AND DISPOSAL.

City.	Year.	Net Cost.	Net Cost per Capita.	Net Cost per Cu. Yd.	Net Cost per Ton.
Cleveland	1907	$84,000	$0.166	$0.505	$1.21
	1908	93,192	.178	.465	1.11
	1909	109,434	.208	.535	1.30
Cincinnati	1907	123,702	.351	.525	1.33
	1908	119,408	.335	.520	1.32
	1909	114,893	.319	.510	1.32
Dayton	1909	26,000	.23	.47	0.80

STREET CLEANING.

The cost of street cleaning in the cities of Ohio varies considerably both as to the amount expended per capita and the unit costs of the work. The amount expended is, of course, dependent upon the fund appropriated for the purpose and the extent of the appropriation governs largely the development of improved methods of cleaning and also the efficiency of the street cleaning departments.

In table No. 23 are given total and unit costs of street cleaning in the three principal Ohio cities. It will be seen that the greatest expenditure is made at Cincinnati while at Cleveland the appropriations, as well as the costs on the basis of area cleaned, are lower. Both cities employ flushing to a great extent; the Cleveland practice being to use the flushing machines alone, while at Cincinnati machine sweepers are used in connection with the flushers.

The costs for Cincinnati include labor and maintenance expense but do not include new equipment or overhead expense. The costs at Cleveland include labor, wagon and team hire, but do not include overhead expense. The costs at Columbus include labor, maintenance, and new equipment but do not include fixed charges.

TABLE NO. 23.

COST OF STREET CLEANING.

City.	Year.	Total Cost.	Cost per Capita.	Cost per Square (10,000 sq. ft.) Cleaned.	Cost per Cu. Yd. Dirt Removed.
Cleveland	1907	$191,301	$0.377	$0.478	$1.13
	1908	194,745	.371	.480	1.11
	1909	186,127	.343	.498	1.14
Cincinnati	1907	159,556	.452	.980	1.76
	1908	210,846	.592	.778	1.42
	1909	229,187	.636	.713	1.77
Columbus	1907	78,289	.478	....	....
	1908	90,190	.530	....	....
	1909	96,285	.547	....	....
	1910	101,148	.561	.530	1.71

In table No. 24 are given the costs of catch basin cleaning at Cincinnati and Cleveland. The costs at Cincinnati include labor and stable maintenance, but not new equipment and fixed charges. Those at Cleveland include labor and wagon and team hire, but not new equipment and overhead expense.

TABLE NO. 24.

COST OF CATCH BASIN CLEANING.

City.	Year.	Total Cost.	Cost per Basin Cleaned.
Cleveland	1907	$17,481	$0.91
	1908	16,284	0.84
	1909	16,492	0.81
Cincinnati	1908	24,036	2.15
	1909	27,596	1.36

APPENDIX I.

DETAILED DESCRIPTIONS OF METHODS OF COLLECTION AND DISPOSAL OF CITY WASTES IN OHIO CITIES.

CLEVELAND,
CINCINNATI,
COLUMBUS,
DAYTON,
CANTON,
MANSFIELD,
MARION,
STEUBENVILLE,
ZANESVILLE.

CLEVELAND.

The city of Cleveland is situated on the shore of Lake Erie at the mouth of the Cuyahoga River. The area included within the corporate limits is about 40 square miles. The main portion of the city lies on a level plateau, the average elevation of which is about 80 feet above lake level. The country beyond this plateau rises in general slopes to elevations of about 300 feet above the lake. The plateau is dissected by the deep valley of the Cuyahoga River, which passes through the city.

The present population of Cleveland according to the 1910 Federal census is 560,663, and in the accompanying table it will be seen that the growth of the city has been very flourishing. The population per square mile is 14,000. This figure indicates greater congestion than exists in any other Ohio city, but as practically all sections within the corporation limits are built up the most congested districts are not so thickly inhabited as those of Cincinnati, where a considerable portion of the area of the city is unoccupied by dwellings.

CLEVELAND POPULATION GROWTH 1880-1910.

Year.	*Population.*	*Percentage Increase During Decade.*
1880	160,146	72.5
1890	261,353	63.2
1900	381,768	46.1
1910	560,663	46.9

Cleveland is one of the most important ports of the Great Lakes and is also a great manufacturing city. Its principal industries are oil refineries, the manufacture of iron and steel, ship building, and meat packing. Owing to the nature of the manufacturing industries the city contains a very large percentage of foreign population. With this foreign laboring class is also associated a large colony of foreigners engaged in small commercial enterprises.

The public water supply of Cleveland is taken from Lake Erie through an intake crib about four miles off shore. The supply is usually of good quality, but to insure its purity at all times there are at present being made plans for its sterilization before use. The sewerage is for the most part constructed on the combined plan and a great number of the outlets are discharged into the Cuyahoga River.

The sewage formerly flowing through outlets into the lake has been diverted by a recently constructed intercepting sewer, which conveys the sewage several miles to the eastward. The streets are almost entirely paved and kept in good repair. At present there are about 350 miles of paved streets, which are constructed principally of vitrified brick.

In the organization of departments for the collection and removal

of waste material and for street cleaning the city has undergone marked advancement. Well equipped and efficiently managed departments now attend to the proper removal of garbage, dead animals, rubbish, ashes, street cleanings, and night soil. The general sanitary conditions of the city as a result of the efforts directed through the various municipal improvements, have greatly improved during the past ten years, and this is no more strikingly illustrated than in the reduction of the total death rate. The city is now one of the most healthful of the state and this must be ascribed to its great development in municipal improvements as well as to its favorable location.

City wastes disposal and street cleaning are under the department of public service, the work being carried out by two sub-departments, namely, the garbage department, and the street cleaning department. The latter department in addition to the regular work of street cleaning, also cares for the collection and disposal of rubbish and ashes.

GARBAGE.

Past Experience.

It was several years previous to 1897 that steps were first taken to effect an organization in the collection and disposal of the garbage of the city. At this time a contractor was engaged in the work, making collections from all portions of the city and disposing of the material by conveying it on barges several miles from the shore and dumping it into the lake. This method of disposal was unsatisfactory, not only because of the littering of the shore with floating debris, but also on account of the excessive cost. During the period previous to 1897, a portion of the garbage of the city was also disposed of by feeding to swine on farms in the outlying districts maintained especially for the purpose. This method of disposal was also unsatisfactory, resulting in diseases among the animals, and was finally condemned by the local health authorities.

In order to improve the collection and disposal of garbage, the city in 1897 awarded to the Buckeye Reduction Company a contract for the work for a period of five years. It was not until August, 1898, that a reduction plant was completed and ready for operation. During the year intervening the contract was sub-let to the Newburg Reduction Company, which company carried out the contract. The contract price was $69,400 per year, to be paid in equal monthly installments. Based on the average population for the five year period, the cost was equivalent to 18 cents per capita, which is somewhat in excess of the cost under municipal ownership.

Collection equipment, consisting of wagons, stables, a loading station, and railroad cars were provided by the company, and a reduction plant built for the final disposal of the garbage. The reduction plant was located at Willow, a small hamlet a few miles south of the city. In

1900 it was remodeled by the Detroit Sanitary Company, and a process practically the same as that known as the Chamberlain process installed. Upon the expiration of the contract with the Buckeye Reduction Company in 1903, no new contract was made with the company, but it was permitted to continue without formal renewal until January 1, 1905, with the same compensation provided for under the contract. During these two years the equipment of the plant was allowed to become in a very poor state of repair.

On January 1, 1905, the entire equipment for the collection and disposal of garbage owned by the Buckeye and Newburg Reduction Companies was taken over by the city and has since been operated under municipal ownership. Owing to the run down condition of the plant, very extensive repairs were required during 1905 to place the plant in proper working order. There was also added an entire new plant, installed by the Edson Reduction Machinery Company of Cleveland. This new plant had a capacity of 60 tons per day and was erected adjoining the old plant at a cost of $64,820. After the installation of the new plant the old process was continued in use to handle a portion of the garbage. During the first year of operation it was found that the Edson plant was incapable of treating the quantity of material guaranteed by the manufacturer, and the city demanded either an enlargement or a refund of $20,500 of the contract price. The latter alternative was chosen by the Edson Company. This refund money was then expended by the city in remodeling the plant along lines devised by J. B. Livingston of Bridgeport, Connecticut, and by E. S. Peck, superintendent of the plant.

The plant in its remodeled condition now cares for all of the garbage of the city, and the Chamberlain and Edson processes have been entirely abandoned. The present process is somewhat different from any in use elsewhere and will be taken up in detail later.

The general methods of garbage collection have remained practically the same as when first undertaken by the Buckeye Reduction Company. In 1907, two years after the purchase of the equipment by the city, extensive changes and improvements were made by the purchase of entire new collection wagons of an improved type; also new steel garbage cars, both changes being in line with improvements in the methods of handling the garbage at the reduction works, made in connection with the remodeling of the plant.

At the present time the garbage is collected from the various portions of the city in specially constructed dump wagons, is delivered to a receiving or dumping station where the material is transferred to dumping cars of a special type, and thence conveyed to the reduction works at Willow.

Present Methods.

The director of public service is in general charge of the organization for the collection and disposal of garbage. Under him are employed two superintendents, one having charge of the collection and the other of the final disposal of the material.

The superintendent of collection has general charge of the equipment and the work of the collection department, hiring all labor and attending to the principal purchases. Under him are employed an inspector, a veterinarian, and about 100 men engaged in the work of collection and the maintenance of the stables. The total daily pay roll of the department is about $200.

The superintendent of disposal is in immediate charge of the reduction works, and hires all labor required. Under him are employed three foremen, one for each 8-hour shift, and about 50 labors and mechanics to attend to the operation of the reduction process.

Character of Territory from Which Collection is Made. Garbage is collected from all portions within the city. The entire area is divided into 70 districts, which number varies with the seasons of the year. The areas of the districts vary from about ¼ square mile to one square mile, the larger ones being situated in the more sparsely built up districts. It is the aim to accurately limit the districts to permit of schedule work in collection in order that more systematic results may be obtained. The inspector of the department is, therefore, constantly engaged in revising the districts. The length of haul varies from one to five miles, and averages for the entire city somewhat over 2.5 miles. In order to permit more efficient work in the outlying districts, empty wagons are sent out with helpers who return with the loaded ones and the work of the collectors is thus not interfered with. In the central business portion of the city, collections are made daily, although owing to the influence of a private rendering company, the large number of hotels and restaurants contribute but a small amount of garbage for city collection. In the residential districts it is the aim to make semi-weekly collections, and this is customary in all but the remote and scattered districts where weekly collections are made.

Equipment for Collection. The collection equipment in general consists of the collection wagons, horses, receiving station stables, railroad cars, and miscellaneous minor equipment. The receiving station and stables are located in almost the geographic center of the city at the edge of the valley of the Cuyahoga River. The buildings are located upon a tract having an area of about 0.3 acre, which is conveniently situated for shipping, as it lies immediately adjacent to a railroad. Its location is, however, objectionable owing to the fact that it must be reached by steep down grades by wagons arriving from almost all portions of the city, and this results in a depreciation of the collection equipment. Most of

the buildings are the same as those used by the reduction company, although improvements, repairs, and a new office building have been added by the city. The buildings are of frame construction and are in a rather dilapidated condition. A large wagon yard is provided for the storage of the collection wagons, as well as for means of dumping into railroad cars. The yard is located at an elevation of about 15 feet above the railroad tracks, so that the cars may be drawn alongside and the material transferred from the wagon bodies by gravity.

The stable is of wooden construction and is in a poor state of repair. There are now about 120 stalls, but to accommodate this number of horses there has been excessive crowding. The stables are poorly ventilated, although every effort is made to keep them clean and sanitary. In connection with the stable is a small room 20 by 20 feet, where all collection wagons are washed daily.

The new type of wagon adopted in 1907 is an innovation, especially adapted to facilitate rapid dumping of the garbage. The wagons are constructed with a strong running gear holding a steel tank body having a length of 10 feet 10 inches at the top, 8 feet 5 inches at the bottom, a width of 4 feet, and a depth of 24 inches. The capacity when loaded level is 2½ cubic yards. The tank body is hinged over the rear axle and by means of a chain hoist the front may be elevated to an almost vertical position. The tank is strengthened by arch steel ribs across the top which also supports the heavy canvas covers. The cost of these wagons was $185 each. The city now owns 100 wagons, which are used exclusively for garbage collection.

The cars used for the transportation of the garbage to the reduction plant, of which there are 10, are of a special type built by the Arthur Koppel Company of Pittsburg, and by the Atlas Car and Manufacturing Company of Cleveland. They are constructed entirely of steel, consisting of a semi-cylindrical body supported upon trunnions and roller bearings on which the body may be revolved. When loaded level the cars have a capacity of 53.7 cubic yards, equivalent to 35 tons of garbage. The cars cost $2,450 each, and have been maintained in excellent repair at a slight expense.

For the collection of dead animals the department maintains two horse ambulances and two small wagons for the collection of small animals. The department also maintains two large trucks used for the collection of hotel garbage in cans. Horses and buggies are supplied for the convenience of the superintendent and inspector.

Method of Collection. In order to facilitate the collection of garbage, an ordinance was passed by the city council in 1897, at the time of the awarding of the contract to the Buckeye Reduction Company. This ordinance required the provision by householders of suitable watertight covered receptacles for garbage and the placing of them within 25 feet of the point reached by the collector on his route. This ordinance

has remained in force and is applied with municipal collection service. The enforcement has been found very difficult, especially among the poorer classes and in the foreign districts. It has been found necessary by the garbage department to permit the use of other receptacles such as boxes, buckets, etc., and these are quite general in certain sections of the city. Where it is believed that the householders can afford the prescribed receptacle this is usually insisted upon, and in the better residential portions of the city receptacles of a suitable and approved type are used.

The development of the system of garbage collection at Cleveland has resulted in almost exact schedules being followed by the various collectors. The complaints made to the department are very few, averaging about thirty per week, of which perhaps fifty per cent are not justifiable.

The collection service in those districts located three or more miles from the receiving station is greatly assisted by the practice of relieving the collector of the necessity of stopping the work of collection to bring loaded wagons to the station. By sending out helpers with empty wagons no interruption in the collection work takes place. The helper returns with the loaded one while the collector resumes his work with the empty wagon.

Final Disposal. The municipal reduction works, as already stated, are located at Willow, which is about two miles south of the southerly corporation limits of the city and about nine miles from the garbage loading station. The plant is situated in the valley of the Cuyahoga River on a tract of land 50 acres in area owned by the city. There are but few houses in the immediate vicinity of the plant, the nearest being located about ¼ mile distant.

The plant comprises a number of buildings, part of which are old and contain the equipment installed by the reduction company, the new buildings housing all of the equipment installed by the city. The buildings comprising the present plant are a green garbage building, where the material is unloaded from the cars; a main building, which contains the digesters and driers, and to which is connected a building containing the grease separating tanks; a percolator building, containing the grease extraction and separating machinery and with which is connected a screen house; and a power building which houses the boiler equipment and electric power plant.

A brief review of the improvements made at the Cleveland plant since its first installation may be of value in connection with a description of the present process. The early plant of the Newburg Reduction Company installed in 1898, was substantially a liquid separating process similar to that used at Cincinnati previous to the addition of an extraction plant. The buildings were of wooden construction cheaply made and unsightly. The garbage arriving at the plant in tank wagon bodies

on flat cars was handled by an electric crane and first subjected to digestion, and after six hours treatment in this manner the free liquor within the mass containing a portion of the grease was forced out and conducted to settling tanks. The cooked garbage or tankage was then removed from the digesters and pressed in hydraulic presses at about 250 pounds per square inch, by means of which all the free liquor was expelled. This liquor containing a portion of the grease was conducted to the same settling tanks before referred to. After passing through a series of settling tanks the grease was removed from the top, the waste water being drawn off from the bottom and wasted into the river. The tankage from the presses was dried, screened and stored for shipment. By this process the dry tankage recovered amounted to from 8 to 10 per cent. of the raw material, while the grease recovered was slightly over 2 per cent.

The installation of the Edson process in 1905 following the purchase by the city provided a plant substantially the same in its operation as the present plant at Dayton. The buildings housing the machinery of the Edson process were of substantial construction and are still employed in the remodeled municipal plant. The garbage was delivered in tank wagon bodies as before and first subjected to treatment in digesters. These digesters instead of having steam admitted directly into the material were heated by a steam jacket enclosing the shell. After digestion the garbage was dropped directly into steam jacketed driers without exposure to the air. These driers are in all respects similar to those used in Dayton, consisting of a cylinder through the center of which extends a shaft provided with stirring arms which agitate the material during drying. The vapors from drying were conducted to a condenser. The process of drying required 16 to 18 hours, and after its completion the tankage was removed to percolators by means of which the grease was extracted by naphtha. The tankage was then stored for shipment. After separation of the grease from the naphtha the former was stored for shipment, the latter being used again.

It will be seen that this process was a very costly one owing to the general use of steam jackets and mechanical stirring devices, the attendant use of power and the depreciation of the machinery. As has been stated, this plant failed to operate according to the guarantee of the company, and after one year's trial the city was refunded $20,500, which was used in remodeling the plant and thereafter the Edson process was discarded, although a portion of the machinery is still used.

The plant as remodeled by the city contains a number of novel and distinctive features. They were worked out largely through experience gained by the superintendent in the operation of the old processes and contained very marked improvements in design.

The old method of unloading the garbage from tank wagon bodies by a crane has been abandoned, and there is now provided a green gar-

bage building where the garbage cars of special type as previously described are emptied. This building is a brick structure, 100 feet in length, 32 feet in width and 30 feet in height. The cars enter the building on an elevated track about 12 feet above the floor level and are dumped by means of chain hoists. The bodies are rotated on the roller bearings and the garbage discharged to the concrete. A large amount of the free water contained in the garbage is drained off through suitable openings and at the present time is discharged directly into the river. This green garbage building is located a short distance from the main building, to the top story of which the garbage is carried by scraper conveyor, discharging through chutes into the digesters. There are sixteen new digesters in the remodeled plant, all the old ones having been removed. The digesters are each 54 inches in diameter by 14 feet deep, and are constructed of 5/8-inch riveted steel plates, the interior being lined with 2-inch cypress lumber. The digesters are provided with a false bottom consisting of a perforated metal disc. On the side of the digester just above the false bottom is a door for removing the tankage, while a coil of steam piping is placed immediately below the false bottom through which the steam for cooking is applied. Steam is admitted directly to the material for a period of six hours at a pressure of 70 to 80 pounds. After digestion is completed steam pressure is applied at the top and the free liquor driven off through a connection at the bottom and conveyed to settling tanks where the grease rises to the top and is skimmed off. The liquor from the bottom of the settling tanks is wasted into the river.

The tankage from the digesters is removed in specially constructed cars, from which it is discharged into a conveyor leading to the driers. The Edson driers used in connection with the old process are now employed to partially dry the tankage. Three driers are provided, each of which is of such capacity as to receive two digesters full at a charge. The material is dried during a period of somewhat over two hours with a steam pressure in the jacket of from 70 to 80 pounds, corresponding to about 320 degrees F. After discharge from the Edson driers the tankage contains about 40 per cent. moisture.

From the Edson driers the material is conveyed to a final drier, which is the design of E. S. Peck, former superintendent of the works. This drier is 30 feet in length and 4 feet 6 inches in diameter, and is set at an angle slightly inclined from the horizontal so that the material passes through it continuously by gravity. The drier is provided with a 2½-inch steam jacket around the outside and a 12-inch steam drum extending through its center. It is also provided with a hot blast, the air being heated by a system of steam coils, located at the discharge end of the drier and drawn by a fan located at the charging end. The cylindrical body of the drier is revolved on roller bearings, the power being supplied by a motor. During drying steam is applied in the jacket and

drum at 70 to 80 pounds pressure and the hot air blast is applied at a temperature of about 250 degrees F. By passage through this drier the moisture content of the tankage is reduced to about 5 per cent.

After drying the material is conveyed to the percolator building situated a short distance from the main building. This building contains the percolator and two grease separators. The percolator is of a special design, devised by E. S. Peck, former superintendent of the works. It consists of a steel cylinder 8 feet in diameter by 15 feet long, set horizontally and resting on bearings on which it may be revolved. An opening is provided at the top through which the charge of tankage is admitted. It is usual to fill the percolator two-thirds full of tankage. It is then flooded with naphtha introduced at the top, and after standing about one-half hour the naphtha is withdrawn and the percolator again flooded with fresh naphtha. This process is repeated until the color of the naphtha indicates that the grease has been almost completely removed. After the last flooding of naphtha is withdrawn the percolator is turned over and steam at 10 to 15 pounds pressure passed through the tankage to remove traces of naphtha. The charge is then dropped to the floor from the percolator. The steaming adds about 10 per cent. of moisture to the tankage, but this is not objectionable The tankage is carried in a conveyor to a revolving screen and after screening is ready for shipment. The screen tailings are dumped near the plant.

The naphtha containing the grease is conducted to separating tanks, of which there are two. These are horizontally placed cylinders 12 feet long by 6 feet in diameter, and have a steam coil along the bottom. The naphtha is evaporated and the vapors condensed and stored for use again. The grease is withdrawn and stored for shipment.

The production of tankage and grease is shown in tables Nos. 25 and 26, which contain monthly quantities of raw garbage and products for 1908 and 1909. It will be seen that during 1908 the total products amounted to 12.71 per cent. and during 1909 to 14.98 per cent. of the raw material. On the basis of the average moisture content the recovery should be greater, and the fact that it is not must be attributed to the waste of liquors from the green garbage and from the grease separating tanks, which liquors carry a large quantity of solid matter. The improvements in operation during 1909 resulted in an increase in the recovery of both tankage and grease and the recovery of the latter represents very high efficiency.

It is of interest to note that the recovery of grease is at its maximum during the late winter and spring months and at its minimum during the late summer months.

TABLE NO. 25.

RAW MATERIAL AND PRODUCTS FROM CLEVELAND REDUCTION PLANT.

1908.

Month.	Garbage Received, Pounds.	Tankage Sold, Pounds.	Grease Sold, Pounds.	Percentage Tankage, Wet Basis.	Percentage Grease, Wet Basis.
January	6,614,900	462,780	239,028	7.00	3.61
February	6,274,800	420,980	219,629	6.71	3.50
March	5,537,000	459,460	247,940	8.30	4.48
April	5,535,800	556,629	240,140	10.05	4.34
May	5,727,000	614,323	252,407	10.73	4.41
June	6,664,200	641,665	230,095	9.63	3.45
July	7,588,000	532,270	227,000	7.01	2.99
August	8,241,200	702,750	218,452	9.26	2.65
September	8,655,800	791,245	218,168	9.14	2.52
October	7,764,000	858,560	251,171	11.05	3.24
November	6,715,200	784,100	230,670	11.68	3.44
December	7,107,000	750,109	280,940	10.47	3.92
Total	82,484,900	7,034,853	2,855,640	9.25	3.46

TABLE NO. 26.

RAW MATERIAL AND PRODUCTS FROM CLEVELAND REDUCTION PLANT.

1909.

Month.	Garbage Received, Pounds.	Tankage Sold, Pounds.	Grease Sold, Pounds.	Percentage Tankage, Wet Basis.	Percentage Grease, Wet Basis.
January	7,022,000	808,400	302,648	11.51	4.31
February	5,976,000	590,280	253,215	9.88	4.24
March	6,401,500	694,660	277,329	10.70	4.33
April	5,921,800	736,927	265,637	12.44	4.48
May	6,352,500	796,591	295,034	12.54	4.64
June	7,915,700	712,932	282,656	9.01	3.57
July	7,901,400	980,529	293,235	12.41	3.71
August	8,824,000	989,020	254,180	11.21	2.88
September	9,606,500	868,960	222,557	9.05	2.32
October	8,686,000	1,000,460	269,518	11.55	3.10
November	8,073,500	1,038,980	292,300	12.87	3.62
December	6,465,400	832,135	292,541	12.87	4.52
Total	89,150,300	10,052,865	3,300,850	11.28	3.70

The quality of the tankage produced is shown in table No. 27 which contains the results of monthly analyses of composite samples made by Dr. W. J. Gascoigne of Baltimore, Maryland, for the city of Cleveland. It will be seen that the percentage of grease remaining in the tankage is kept quite low, averaging 2.68 per cent. for the year, and this indicates efficiency in the processes of its removal. It is also of interest to note the variation in the nitrogen and phosphoric acid contents. The analyses show minimum values for these constituents during the summer months, the maximum values occurring during the winter season.

TABLE NO. 27.

ANALYSES OF CARBAGE TANKAGE.

By Dr. W. J. Gascoigne, Baltimore, Maryland.

1909.

Month.	H_2O at 100°.	Nitrogen.	P_2O_5.	K_2O.	Grease.	No. Cars Sampled.
January	6.38	3.56	5.05	.33	2.55	14
February	4.03	3.55	4.66	.55	3.32	4
March	8.79	3.18	4.53	.65	2.71	13
April	10.72	3.05	4.40	.74	1.23	11
May	13.57	2.91	4.08	.64	4.33	12
June	13.13	2.84	4.21	.86	1.49	12
July	14.89	2.72	3.95	.74	3.19	18
August	15.28	2.65	3.53	.59	1.55	17
September	15.41	2.68	3.49	.83	2.78	17
October	7.93	3.03	4.15	.62	3.90	18
November	10.80	3.27	5.14	.54	3.27	19
December	9.71	3.28	4.95	.51	1.81	14
Average	10.99	3.06	4.34	.63	2.68	.....

The average analyses of three samples of tankage collected and analyzed during the studies herein described are as follows:

Per cent. moisture	15.92
Per cent. ash	27.42
Per cent. combustible	56.66
Calorific value (B T U)	5556
Per cent. ether extract	1.22
Per cent. phosphoric acid (P_2O_5)	3.68
Per cent. nitrogen	2.82
Per cent. potash (K_2O)	0.46

It will be noted that these average results indicate a lower content of ether extract, P_2O_5, nitrogen, and K_2O than the averages of the Gas-

gicone analyses given previously. This may be due to the use of different methods of determination.

Quantity of Garbage Collected. The quantities of garbage collected are given in table No. 28 which contains monthly records for 1908 and 1909 and unit quantities for the same period. In table No. 29 are also given the annual total and unit quantities from available records kept by the department. An examination of table No. 28 will indicate the fluctuations which take place during the different seasons of the year in the quantity of material collected, showing that the maximum occurs during the summer months and the minimum during the late winter and spring seasons. It is also of interest to note in table No. 29 the gradual increase in the per capita quantities during successive years. This result is brought about largely by increased efficiency in the collection department. It should be remembered that the quantities of material available for city collection are limited by two principal factors, namely, the existence of a private collecting company which removes a large portion of the hotel, restaurant and apartment house garbage, and the presence of a large percentage of foreign population which are low producers of garbage.

TABLE NO. 28.

QUANTITIES OF GARBAGE COLLECTED.

Month.	1908.				1909.			
	Cu. Yds.	Tons.	Cubic Yards per Capita.	Pounds per Capita.	Cu. Yds.	Tons.	Cubic Yards per Capita.	Pounds per Capita.
January	5,585	3,307	.0106	.0126	5,370	3,511	.0099	13.0
February	4,833	3,137	.0092	.0119	4,510	2,988	.0083	11.0
March	4,672	2,769	.0089	.0105	4,779	3,200	.0088	11.8
April	4,440	2,854	.0094	.0109	4,510	2,961	.0083	10.9
May	5,045	2,864	.0096	.0109	4,726	3,186	.0087	11.7
June	5,640	3,332	.0107	.0127	5,420	3,966	.0100	14.6
July	5,850	3,794	.0112	.0145	5,745	3,955	.0106	14.6
August	6,285	4,126	.0120	.0157	6,713	4,412	.0124	16.3
September	6,660	4,327	.0126	.0165	6,713	4,803	.0124	17.8
October	5,910	3,882	.0113	.0147	6,014	4,348	.0111	16.0
November	5,100	3,358	.0097	.0128	5,585	4,037	.0103	14.9
December	5,477	3,584	.0105	.0137	5,800	3,233	.0107	11.9
Total	65,997	41,334	.1257	.1574	65,885	44,600	.1215	164.5

TABLE NO. 29.

UNIT QUANTITIES OF GARBAGE COLLECTED.

Year.	Tons.	Pounds per Capita. per Year.	Tons per Working Day.
1899	22,379	121	71.5
1904	24,687	110	78.9
1905	30,382	130	97.1
1906	34,891	144	111.5
1907	37,606	148	121.1
1908	41,334	157	132.1
1909	44,600	161	142.5

Character of Garbage. The physical and chemical character of the Cleveland garbage is discussed in a previous portion of this report in connection with a consideration of the garbage of the other Ohio cities. The Cleveland garbage does not differ noticeably from that of the other cities of the state, except in the fact that during the investigation herein described it was of a generally cleaner and fresher appearance, the result no doubt of greater frequency of collection. The composition of the garbage is shown in a tabulation of analyses in an appendix to this report. Its composition is quite similar to that of Cincinnati and Columbus.

Cost Data. In table No. 30 are shown valuations made by appraisal on December 31, 1910 of the real estate and equipment of the garbage department. On the basis of population in 1910 the costs and valuations are as follows:

	Original Costs per 1,000 Population	*Value 1910 per 1,000 Population*
Collection equipment	$173.18	$105.90
Disposal equipment	414.48	293.38
Total	$587.66	$399.28

TABLE NO. 30.

VALUE OF COLLECTION AND DISPOSAL.

LAND, PLANT AND EQUIPMENT.

December 31, 1910.

COLLECTION EQUIPMENT.

Collection equipment	$96,980.49		
Less depreciation	37,675.84		
		$59,304.65	
Total			$59,304.65

DISPOSAL EQUIPMENT.

Land		$25,000.00	
Buildings	$76,441.49		
Less depreciation	18,189.04		
		$58,252.45	
Machinery	$130,666.30		
Less depreciation	49,624.69		
		81,041.61	
Total			$164,294.06
Total collection and disposal equipment			$223,598.71

In table No. 31 are exhibited itemized expenses for collection and transportation of garbage to the reduction works during 1905, 1906, 1907, 1909 and 1910. In table No. 32 are presented the itemized expenses at the disposal plant and in table No. 33 are given the extraordinary expenses of the garbage department. Table No. 34 shows the gross income of the department during those years. A summary of the income and expenditures is given in table No. 35.

It will be noted that in none of the tables are interest charges included. On the basis of the figures given in the following tables of cost, the unit costs have been computed and are presented in table No. 36. It is of interest to note that with increased cost of both collection and disposal on the tonnage basis the net cost of the entire work has shown an appreciable decrease due to improved processes used at the reduction works.

TABLE NO. 31.

COST OF COLLECTION AND SHIPPING OF GARBAGE AT CLEVELAND.

Items.	1905	1906	1907	1909	1910
Labor, teamsters, etc.	$37,826	$43,829	$54,100	$58,976	$72,344
Feed	9,168	10,991	16,640	16,111	16,241
Railroad freight	4,561	5,285	5,824	6,587	6,260
Superintendence and clerk hire	2,112	2,870	2,430	3,700	2,043
Shoeing	1,953	2,431	3,132	2,666	2,495
Harness repairs and renewals	784	1,204	1,189	1,301	2,086
Repairs and renewals to freight cars, wagons, etc.	4,146	5,199	5,571	2,712	5,608
Rent, Canal Street (including taxes)	559	473	.....	.....	.....
Insurance	450	450	526	655	879
All other sundries	1,245	1,601	3,220	4,103	5,181
Total	$62,804	$74,334	$92,632	$96,811	$113,137

TABLE NO. 32.

GROSS COST OF DISPOSAL OF GARBAGE AT CLEVELAND.

Items.	1905	1906	1907	1909	1910
Labor	$26,735	$43,732	$44,185	$40,417	$43,526
Coal and gas	10,974	19,980	16,370	25,589	25,268
Superintendence and clerk hire	3,895	3,363	3,497	4,000	3,786
Repairs and renewals	7,110	4,763	8,076	11,242	7,306
Press cloth	1,290	2,565	3,161	.....	.....
Press racks	231	806	966	.....	.....
Insurance	314	288	187	.....	.....
Office supplies	124	146	386	396	199
All other sundries	1,921	5,113	5,332	3,559	2,184
Taxes	.....	346	459	714	.....
Freight on product, purchase of dead animals, etc.	1,855	1,455	2,203	.....	124
Commission, analyses, etc	.....	826	472	343	524
Gasoline	.....	.....	.....	2,486	2,390
Total	$54,449	$83,384	$85,294	$88,746	$85,307

TABLE NO. 33.

EXTRAORDINARY EXPENSES OF COLLECTION AND DISPOSAL OF GARBAGE AT CLEVELAND.

Items.	1905	1906	1907	1909	1910
Repairs and renewals on account of fire	$3,082	.....	.....	.....	.....
Auditing	150	$150	$300	$150	.....
Losses on horses, cars, etc	250	1,473	697	1,440	$1,645
Depreciation on disposal equipment, 10% per year	3,154	3,918	9,902	16,175	16,630
Depreciation on collection equipment, 10% per year	2,860	3,351	4,799	8,694	9,919
Total	$9,496	$8,892	$15,698	$26,459	$28,194

TABLE NO. 34.

GROSS INCOME FROM DISPOSAL OF GARBAGE AT CLEVELAND.

Items.	1905	1906	1907	1909	1910
Sale of product	$57,335	$96,351	$116,324	$148,855	$173,322
Inventory of product	5,563	8,694	11,979	11,242	16,839
Sale of raw material	559	354	479	326	44
Rents	130	127	101	96	56
Miscellaneous, Collection department	2,294	1,465	378	351	391
Total	$65,881	$106,990	$129,231	$160,870	$190,652

TABLE NO. 35.

SUMMARY OF INCOME AND EXPENSES FOR COLLECTION AND DISPOSAL OF GARBAGE AT CLEVELAND.

Items.	1905	1906	1907	1909	1910
Total Expenses:					
Collection	$62,804	$74,334	$92,632	$96,811	$113,137
Disposal	54,449	83,384	85,294	88,746	85,307
Extraordinary	9,496	8,892	15,698	26,459	28,194
	$126,749	$166,610	$193,624	$212,016	$226,638
Total income	65,881	106,990	129,231	160,870	190,652
Net operating expenses	$60,868	$59,620	$63,393	$51,146	$35,986

TABLE NO. 36.

UNIT COSTS OF COLLECTION AND DISPOSAL OF GARBAGE AT CLEVELAND.

	1905	1906	1907	1909	1910
Total cost of collection*	$65,989	$79,233	$98,278	$107,020	$124,701
Per capita	0.14	$.16	0.20	0.197	0.222
Per ton garbage	2.17	2.27	2.62	2.40	2.79
Total cost of disposal*	60,760	87,377	95,346	104,996	101,937
Per capita	0.13	0.18	0.19	0.193	0.182
Per ton	2.00	2.53	2.54	2.35	2.28
Net profit of disposal†	5,121	19,613	33,885	55,874	85,715
Per capita	0.011	0.041	0.067	0.103	0.153
Per ton	0.167	0.562	0.902	1.25	1.92
Net cost collection and disposal‡	60,868	59,620	63,393	51,146	35,986
Per capita	0.13	0.12	0.125	0.094	0.064
Per ton	2.00	1.71	1.68	1.14	0.804

* Including extraordinary expense.
† Including gross income less cost of disposal.
‡ Total cost less gross income.

DEAD ANIMALS.

The collection and disposal of dead animals constitute a portion of the duties of the garbage department. The city maintains for the purpose two large ambulances for collecting dead horses, cows, etc., and two express wagons for the removal of small animals. The removal of large animals is also looked after by a privately operated rendering company, which pays the owners for the privilege of removing the carcasses. This company has succeeded in obtaining the majority of the dead horses and cows of the city. To compete with this company the city also pays for the carcasses collected. The animals are carted directly to the reduction works and there handled in the same manner as the garbage. No record

is available showing the number of large animals thus collected by the city, but approximate figures fix the number at 50 per month.

The smaller animals, dogs, cats, etc., are entirely collected by the garbage department, loaded on the garbage cars, and handled with the garbage at the reduction works. As an indication of the extent of this work the total number of small animals collected during 1908 and 1909 were 5,392 and 6,220, respectively. Cost data for this work is included in cost of garbage collection.

RUBBISH AND ASHES.

Previous to 1906 ashes and rubbish were collected entirely by private scavengers, unlicensed, and only in a general way under the supervision of the health department. The collections were infrequent and irregular and the city was incompletely covered by the routes of the several collectors. The material was disposed of by dumping into vacant lots, at the sides of roadways and wherever dumping could be carried on without causing immediate complaint.

In July, 1906, the city undertook the collection of ashes and rubbish primarily for the purpose of removing the nuisance attending the littering of the streets and alleys of the city, but also in order that systematic dumping could be followed and some satisfactory results thus obtained.

The present organization of the rubbish and ashes department places it under the street cleaning department, whose superintendent and assistant have charge of the work. Five inspectors are employed, whose duty it is to cover the city and inspect both street cleaning and rubbish and ashes collection. On the various dumps used laborers are employed to direct the dumping of the material and maintain proper conditions. Each collection wagon is manned by a driver and helper, the total number of laborers employed in the department being about 150. The daily payroll of the department, including supervision, is about $375.

Character of Territory from which Collection is Made. The operations of the rubbish and ashes collection department extend over the entire city. The territory is divided into a number of districts laid out for the principal purpose of minimizing the length of haul to the dumping grounds. The districts are frequently changed at the discretion of the superintendent or inspectors of the department. The average length of haul for the collection wagons in carrying the material from their respective districts to the dumping grounds is about 1¼ miles, and the maximum haul for certain districts which are somewhat removed from available dumps is two miles The collection wagons make one or more trips per day and where the haul is short as many as four or five loads are collected. The average for all of the wagons is 2½ trips per day. The area of the collection district assigned to each wagon is such that weekly collection can be made in the greater portion of the city and

semi-weekly collection in the central portion. A few of the outlying districts receive somewhat less frequent attention.

Equipment. Since the organization of the department in 1906 there has been a constant development in the equipment provided. The department now has some 90 collection wagons, but owns no horses or mules, these being hired with drivers by the day. The collection wagons are of the bottom dump type, have capacities of 3½ to 4 yards, and cost $150 each. For convenience the equipment is maintained at the various street cleaning stations located throughout the city.

Methods of Collection. Rules and regulations have been adopted by the department to facilitate the work of collection. These rules necessitate the provision of suitable receptacles, the exclusion of garbage, and the tying of all loose refuse into bundles. These rules have been difficult to enforce completely, but with the growing efficiency of the department the householders are becoming educated to the advantage of the rules and their observance is increasing.

In order to avoid the objection of dumping large quantities of waste paper with the material, as well as to realize its commercial value, the department conducts a separate waste paper collection, 20 wagons being used in this work. Gunny sacks are provided to the householder and each week the waste paper collectors empty the sacks, returning the same sacks to the householder to avoid possible infection. The waste paper is taken to conveniently located baling stations. This separate collection of waste paper has done much to avoid dump nuisances as well as to afford an income to the department.

During the first year of operation of the collection department complaints from the householders were frequent, but owing to the few years of its development and the growing appreciation by the people the complaints have almost entirely disappeared. The collection work is now in a high state of efficiency.

Disposal. All rubbish and ashes collected are disposed of by dumping upon land The location of the dumps, of which there are about 25, was selected for the purpose of the recovery of land rather than on account of suitable surroundings. The park department of the city has purchased several sites which the rubbish department is at present improving by filling, and when completed the city will establish public parks and playgrounds. Several deep fills are being made also for the purpose of carrying streets across deep ravines and thus avoid bridge construction.

There are five principal dumping grounds, the remaining ones being small and unimportant. These larger dumps are known as the Lake Front Dump, the 55th Street Dump, the 79th Street Dump, the Case Avenue Dump, and the Walworth Sewer Dump.

The Lake Front Dump is one of the largest used and is situated at the shore of the lake opposite the central portion of the city. The dump was first begun by dumping directly into the lake, a breakwater being

constructed to prevent the washing away of the material. There have been recovered up to the present time about 100 acres of land. The principal filling material has been street cleanings and cellar excavations, and the land is therefore suitable for building. This location will probably be selected as a site for a new Union Station.

The 55th Street Dump is also located on the shore of the lake at the foot of 55th Street. The property being filled is privately owned by the Rockefeller Salt Company. Here a number of acres of land have already been reclaimed. The quality of material received is not so favorable for filling as the Lake Front Dump, consisting principally of rubbish, ashes and street cleanings, and containing a very much smaller percentage of cellar excavations.

The 79th Street Dump, covering an area of 67 acres, is owned by the city. Here a street has been carried across a ravine which has a depth of 50 to 60 feet. A very large percentage of rubbish is received at this dump and some trouble has been experienced on account of burning. The dump is surrounded by built-up districts.

The Case Avenue Dump is located in a ravine occupied by Kingsbury Run in the east central portion of the city. The dump is 60 to 70 feet high and the fill is for the purpose of carrying the several streets across the ravine. Owing to its great height this dump settles very rapidly and must be carefully watched. It has also given trouble from fires which are difficult to extinguish. The surrounding territory is built up with factories and residences of a poor class and its location is not objected to.

The Walworth Sewer Dump, as its name implies, is located over the course of the Walworth intercepting sewer which passes through the southern portion of the city. The back fill of the sewer is being made with waste material, and it is proposed ultimately to construct a road which will extend the length of the valley occupied by the sewer. The character of the material dumped is principally rubbish and ashes, and this may cause objections in the future if excavations are necessary to enter the sewer.

On all of the dumps the method of dumping is the same. The material is dropped from the wagons at the edge of the slope and after partial picking is shoveled over the edge by hand. The city maintains one or more laborers on each of the dumps to attend to this work, and all of the dumps are thus maintained in good condition. In general the dumps have not been complained of seriously on account of odors, although in the vicinity of some of the dumps, notably the 79th Street Dump, trouble has been experienced on account of littering the streets and yards with light material transported by the wind. Special efforts have been made to prevent fires at the dump and this has avoided considerable complaint.

In connection with the maintenance of the dumps the caretakers are expected to recover saleable portions of the material, consisting prin-

cipally of rags, metal and papers, and these are daily removed to the baling stations.

Quantities of Rubbish and Ashes Collected. The quantities of rubbish and ashes collected as obtained from local records are presented in tables Nos. 37 and 38, which show the monthly total and unit quantities and the annual total and unit quantities, respectively. It will be noted that while there is only a slight variation with the seasons, the minimum collection occurs during the summer months. The annual records show a large increase in the quantities collected during 1908 and 1909 over the collection of 1907, and this is without doubt due to increased efficiency of the department.

TABLE NO. 37.

QUANTITIES OF RUBBISH AND ASHES COLLECTED.

	1908				1909			
	Cu. Yds.	Tons.*	Cu. Yds. per Capita.	Pounds per Capita.	Cu. Yds.	Tons.*	Cu. Yds. per Capita.	Pounds per Capita.
January	21,164	10,910	.0498	41.6	23,189	9,670	.0427	35.6
February	15,872	6,619	.0302	25.2	16,168	6,742	.0298	24.8
March	19,904	8,300	.0379	31.7	23,345	9,735	.0430	35.9
April	18,220	7,598	.0347	29.0	19,387	8,084	.0357	29.9
May	18,828	7,851	.0359	29.9	17,684	7,374	.0325	27.2
June	12,308	5,132	.0234	19.6	16,938	7,063	.0312	26.0
July	16,808	7,009	.0320	26.6	14,592	6,085	.0269	22.4
August	12,984	5,414	.0247	20.6	15,546	6,483	.0286	23.9
September	12,148	5,066	.0232	19.3	12,863	5,364	.0238	19.8
October	13,828	5,767	.0364	21.9	14,994	6,252	.0276	23.0
November	16,428	6,850	.0312	26.1	16,938	7,063	.0212	26.0
December	17,164	7,157	.0327	27.2	11,108	4,632	.0204	17.1
Total	200,656	83,673	.3821	318.7	202,752	84,547	.3734	311.6

*Tonnage estimated at 834 pounds per cubic yard.

TABLE NO. 38.

UNIT QUANTITIES RUBBISH AND ASHES COLLECTED.

1907-1909.

	Cu. Yds.	Tons.	Cu. Yds. per Capita.	Pounds per Capita.	Cu. Yds. per Working Day.
1907	167,084	69,674	.3295	265	533
1908	200,656	83,673	.3821	319	641
1909	202,752	84,547	.3734	311.6	641

Character of Material. Observations of the appearance of the rubbish and ashes at Cleveland do not indicate that it is greatly different from that of other cities. The mechanical analyses made in the field, however, show that the percentage of paper is noticeably reduced by the separate waste paper collection. In an appendix will be found a tabulation of these analyses as well as laboratory determinations upon the ash content. The character of the material has been discussed in a previous portion of this report.

Cost Data. The cost of rubbish and ashes collection for the years 1907 to 1909 is presented in table No. 39 which contains the total cost and net cost after deducting the earnings from sale of rubbish.

TABLE NO. 39.

COST OF RUBBISH AND ASHES COLLECTED.

1907-1909.

	Total Cost.	Earnings.	Net Cost.
1907	$87,392	$3,392	$84,000
1908	99,999	16,807	93,192
1909	119,982	10,548	109,434

In table No. 40 are presented unit costs on the basis of the net operating expenses given in table No. 39.

TABLE NO. 40.

UNIT COSTS OF RUBBISH AND ASHES COLLECTED.

1907-1909.

	Net Cost.	Cost Per Capita.	Cost per Cu. Yd.	Cost per Ton.
1907	$84,000	.166	.505	1.21
1908	93,192	.178	.465	1.11
1909	109,434	.208	.535	1.30

STREET CLEANING.

Municipal street cleaning at Cleveland has been carried on for a number of years. In the organization of the department there has been no marked change, although its development especially during the past

five years has been very marked. The most important changes which have occurred recently have been in the methods of cleaning, and at the present time the machine sweeping method has been practically discarded, having been supplanted by flushing and hand cleaning.

Present Methods.

The street cleaning department is organized similarly to the rubbish department, being in charge of the same superintendent and assistant superintendent. Five inspectors and ten foremen are employed to look after the details of the work. There are from 300 to 325 laborers regularly employed in the department and at times this number is increased.

The length of streets covered by the street cleaning department is in the neighborhood of 350 miles, giving an average of slightly over one mile to the man. This figure may explain the completeness with which street cleaning is carried on at Cleveland. The city is divided into districts and for convenience several stations are located in various portions of the city where the equipment is maintained and the foremen have offices.

Equipment. The equipment of the street cleaning department consists of one central and several auxiliary barns; some 30 flushing machines; 24 machine sweepers (rarely used); 8 sprinkling carts, and some 130 white wing outfits. No wagons, horses or mules are owned by the department, all being hired with drivers.

The flushing machines are of three types, known as the Sanitary, the St. Louis, and the Cleveland. They differ in details of construction, but modifications locally made have rendered them similar in their operation. All flushers are equipped with a noozle of special design, devised by the superintendent of the department. The sweeping machines, which are of the Austin and Ostler types, are seldom used, being employed only on streets in a very bad state of repair. The sprinkling wagons are of the Studebaker type and are used only during the very hot summer months for sprinkling in the congested portions of the city. The white wing outfits consist of hand carts carrying galvanized iron cans, shovels, scrapers and brooms. The dirt wagons are of the bottom dump type, and have capacities of from 3 to 4 yards.

Methods of Street Cleaning. During the past five years extensive changes have taken place in the method of street cleaning. The availability of plenty of water and the presence of well paved streets have encouraged the development of flushing for street cleaning, and this has grown to be a widely used method. Hand cleaning is extensively used, especially in the busy section of the city.

The flushing method has been studied by the superintendent of the department, and as a result of the observation it is customary to use two,

four or six machines in a group. It has been found advisable to use as many machines working together as possible and that thus the surface of the street is more quickly and efficiently cleaned. With the machines working together two or three are used following one another according to the width of the street. After the material which is washed into the gutters has drained sufficiently it is removed by pick-up gangs and loaded into a dirt wagon.

The hand cleaning method is used on about 30 miles of the streets. The areas assigned to each man employed are such that he is able to cover it three times daily and the street is thus maintained in a very clean condition. The material is placed in cans at the curb and removed during the day by pick-up wagons. The cans are emptied directly into the wagon and this is usually accompanied by the spreading of dust on dry and windy days.

In table No. 41 are given the areas cleaned by the various methods during 1907, 1908 and 1909. It will be noted that the hand cleaning method has been used very much more extensively than any other. The large percentage of the total area cleaned by this method is due largely to the frequency of cleaning where the white wing process is used. The street area cleaned by flushing is larger than that cleaned by white wings, although the less frequent cleaning by this method reduces the total area cleaned as represented in table No. 41.

TABLE NO. 41.

AREAS CLEANED BY VARIOUS METHODS.

1907-1909.

(In great squares — 10,000 sq. ft.)

	1907		1908		1909	
	Squares Cleaned.	Percentage.	Squares Cleaned.	Percentage.	Squares Cleaned.	Percentage.
Flushing	66,595	16.7	75,095	18.5	54,475	14.6
Machine sweeping	1,130	0.3	1,478	0.4	605	0.1
White wings	331,597	82.9	328,810	81.1	318,800	85.3
Machine scrapers	252	0.1	.....	.....	.....	.....
Total	399,574	100.0	405,381	100.0	373,880	100.0

Final Disposal. All street cleanings are disposed of by dumping on land at the same points used for the disposal of rubbish and ashes. The

material is usually employed for surfacing and is satisfactory for this purpose when wetted sufficiently to avoid the creation of dust. The white wing cleanings are usually objectionable for this reason and their dumping is attended by the spreading of dust in the vicinity.

Snow Removal. The removal of snow from the principal streets of the city is cared for by the street cleaning department and by additional labor employed as required. The material is all disposed of by dumping into the sewers or directly into the Cuyahoga River.

Quantities of Street Cleanings Removed. In table No. 42 are given quantities of street cleanings removed during 1908 and 1909. It will be noted that the greatest activity in the department occurs during the spring months, due, no doubt, to enforced neglect of the streets during the winter months when the quantities removed are at their minimum. Fairly regular work is done during other portions of the year.

TABLE NO. 42.

QUANTITIES OF STREET CLEANINGS COLLECTED.

	1908		1909	
	Cu. Yds.	Cu. Yds. per Capita.	Cu. Yds.	Cu. Yds. per Capita.
January	10,539	.0205	5,544	.0102
February	1,232	.0023	2,366	.0043
March	34,951	.0665	13,584	.0250
April	22,169	.0422	29,676	.0550
May	17,062	.0324	15,648	.0288
June	18,088	.0344	13,388	.0246
July	15,505	.0295	17,129	.0315
August	15,865	.0302	15,876	.0292
September	14,466	.0275	15,802	.0291
October	18,315	.0348	14,973	.0276
November	5,509	.0105	15,992	.0294
December	3,490	.0067	7,133	.0131
Total	177,191	.3375	167,111	.3078

In connection with a study of the quantities of street cleanings, it is of interest to note the amount of material removed per unit area cleaned. In table No. 43 this data is given for 1907, 1908 and 1909.

TABLE NO. 43.

QUANTITIES OF STREET CLEANINGS PER GREAT SQUARE.

	Cu. Yds. Removed.	Great Squares Cleaned.	Cu. Yds. per Great Square.
1907	170,000	399,574	.425
1908	177,191	405,381	.437
1909	167,111	373,880	.447

Cost Data. The total cost of street cleaning for 1907, 1908 and 1909 is given in table No. 44. These costs include labor, maintenance, equipment and repairs, but do not include supervision expense or fixed charges.

TABLE NO. 44.

COST OF STREET CLEANING.

	Total Cost.	Cost per Capita.	Cost per Cu. Yd. Material Removed.	Cost per Great Square Cleaned.
1907	$191,301	$0.377	$1.13	$0.478
1908	194,745	.371	1.11	.480
1909	186,127	.343	1.14	.498

The cost of cleaning by the various methods as given in records of the street cleaning department are given in table No. 45. These costs include no overhead expense.

TABLE NO. 45.

COST OF STREET CLEANING BY VARIOUS METHODS.

Cost per Great Square Cleaned.

	1907	1908	1909
Flushing	$0.40	$0.38	$0.36
Machine Sweepers	0.41	0.41	0.44
Pick-up Gangs	0.89	0.68	0.76
White Wings	0.17	0.15	0.14
Machine Scrapers	0.47	.....	.....

CATCH BASINS.

Previous to 1904 catch basin cleaning was carried on under the supervision of the engineering department of the city, which has general charge of the sewerage system. Since that time, however, the work has been done by the street cleaning department, a separate corps of laborers being provided for the purpose. The organization of the department includes two inspectors and about 25 laborers, and the total daily pay roll is in the neighborhood of $60, including supervision.

Previous to the inception of flushing as a method of street cleaning, the catch basins, of which there are about 18,000 in the city, were cleaned on an average once each year, but with the general use of flushers the necessity of cleaning has increased and most of the catch basins must be cleaned every eight or nine months.

The equipment of the department for the purpose consists of special tools for cleaning. All teams and wagons for carting the material are hired.

The material removed from catch basins as a rule is of no more offensive nature than street cleanings, although it is objectionable when it contains putrefactive matter. It is disposed of entirely by dumping in the same manner as the street sweepings and creates no nuisance at the dumps.

Cost Data. The cost of catch basin cleaning is given in table No. 46.

TABLE NO. 46.

COST OF CATCH BASIN CLEANING.

	Total Cost.	Number Basins Cleaned.	Cost per Basin.
1907	$17,481	19,280	0.91
1908	16,285	19,286	0.84
1909	16,492	20,140	0.82

NIGHT SOIL.

The collection and disposal of night soil has until the past few years been carried on by licensed contractors. The material was disposed of by dumping and burying, and in numerous instances its improper disposal gave rise to complaint. In order to improve conditions municipal collection and disposal of night soil was undertaken by the city a few years ago. With the inauguration of city collection, the work of private collectors was stopped by ordinance.

The department for the collection of this waste is in charge of a superintendent and about 12 laborers are regularly employed. The daily pay roll is about $30. The equipment owned includes 4 wagons and 8 horses. Each wagon is constructed to carry 20 watertight barrels, in which the material is removed. The operation of the department is confined to night work, the hours of collection being between 10 P. M. and 5 A. M. The property owners pay the city for the cleaning of vaults and removal of night soil at the rate of $1.50 per cubic yard. The quantity of material collected amounts to about 6,000 cubic yards per year.

During the first years of municipal night soil collection the material was disposed of by barging and dumping it into Lake Erie. In 1910 this practice was discontinued and the material is now dumped into the large intercepting sewers which carry it to the Cuyahoga River or Lake Erie.

CINCINNATI.

The city of Cincinnati is located in the southwestern corner of Ohio upon the Ohio River a short distance above its confluence with the Great Miami. The area included within the corporation limits in 1910 was 43 square miles. The topography in the central built up portion of the city is flat, but in the outlying districts where the principal residential sections are located the topography is very hilly, the elevation ranging from 100 to 200 feet above that of the business portion. The effect of the topography upon the removal of waste it will be seen introduces an important factor. The population in the city in 1910 was 363,591, and in the accompanying table it will be noted that a steady but gradual growth has taken place since 1880.

Year.	*Population.*	*Percentage Increase.*
1880	255,139	....
1890	296,908	16.3
1900	325,902	9.7
1910	363,591	11.5

The present population of the entire city represents an average of 8,500 per square mile.

Cincinnati is one of the great manufacturing centers of the middle west and contains a great variety of large and important industries. Its population is similar to that of other large cities but differs from certain of them in the fact that the foreign population is almost entirely lacking. Cincinnati is known quite generally as a city of German inhabitants, and this is true to perhaps a greater extent than in any other city in the country.

In municipal improvements the city has made marked advancement. A public water supply of extraordinary quality has been secured by the installation of a mechanical filter plant by which the Ohio River water is purified. This plant was installed in 1908 and has been operated continuously since. The city is well supplied with sewerage and drainage facilities, although the proper disposal of the sewage has been given little attention. Mill Creek, a stream that passes through the city, receives a large amount of the sewage, and objectionable conditions prevail. The collection of rubbish, ashes, and garbage has been provided for a great number of years. The garbage collection is, however, not municipally conducted, being left to a private company. The city maintains a very efficient and well organized street cleaning department which has been operated municipally since 1865.

The collection and disposal of city wastes is carried on under the general supervision of the public service department. Under this department the street cleaning department has charge of street and catch basin

cleaning and also the collection of rubbish and ashes. Garbage collection and disposal, while under the general supervision of the street cleaning department, is carried on by The Cincinnati Reduction Company under a contract with the municipality.

GARBAGE.

Previous to 1865 the collection and disposal of garbage was carried on by scavengers. In that year, however, in connection with the establishment of a street cleaning department, the city inaugurated a combined system of collection for garbage, rubbish, and ashes. The material thus collected was disposed of principally by dumping on land at convenient points in various portions of the city. During the early years a large portion of the garbage was also removed by farmers and fed to swine. Some of the loads collected by the city and consisting principally of garbage were buried at the dumps. This precaution was taken to avoid nuisance, and it also became the custom to use large quantities of disinfectants at the dump. It was impossible, however, to avoid the creation of objectionable odors as putrefaction set in, and the dumps became nuisances in their vicinity. The nuisances were accentuated by the fact that it was impossible to prevent the dumps catching fire and the gases and smoke given off gave rise to serious complaints.

In 1897 the city began a separate collection of garbage and rubbish-ashes. The separation of the waste was more complete in the central portion of the city and combined collection was carried on for several years in the outskirts. At this time the disposal of the garbage was contracted for by the Keck Fertilizer Company. This company operated scows on the Ohio River, conveying the material from the city to a reduction plant located on the site of the present works of the Cincinnati Reduction Company. The garbage was picked over on its way to the plant and a considerable quantity dumped into the stream. This method of collection and disposal was carried on for several years, but was not satisfactory.

In 1902 the city awarded a contract to the Cincinnati Reduction Company for the "collection, removal and disposal of garbage, dead animals, and animal offal from dwellings, hotels, stock yards, slaughter houses, markets, streets, alleys, lands, lanes, squares and public places of the city." The contract provided payment to the company of $74,700 for the first year, and for an increasing scale of $2,000 per year thereafter to provide for extension of the work with the growth of the city. The Cincinnati Reduction Company provided the necessary collection equipment, loading station, cars, and reduction works for the proper handling of garbage. The contract was written for a term of ten years and will expire in 1913.

Present Methods.

The Cincinnati Reduction Company, while operated as a private company is, nevertheless, under the general inspection of the street cleaning department to which its work must be satisfactory. The reduction company has as its head a general manager, who is also secretary of the company, and he gives his personal attention to the operation of both the collection and disposal departments.

Character of the Territory from which Collections are Made. By the terms of its contract the Cincinnati Reduction Company makes collections of garbage from all sections within the corporate limits of the city. The frequency of collection varies with the character of the district, but in no case is the collection less frequent than weekly. In the built-up business portion daily and even semi-daily collections are made. The reduction company also collects all market wastes, slaughter house offal and dead animals within the city.

The average length of haul in conveying the garbage from the point of collection to the loading station averages somewhat over 2½ miles. The maximum haul from the outlying districts is about six miles, while the minimum haul is about one-half mile. The average haul for the material collected from the central portion of the city is two miles.

Rules governing the collection of the garbage and applying particularly to its preparation by the householder have been issued by the city and the reduction company, but difficulty has been experienced in their proper enforcement. The main trouble seems to lie in the tendency of the people to mix garbage and rubbish in preparing it for collection. This tendency has no doubt resulted from the previous mixed collection.

Equipment. The collection equipment of the Cincinnati Reduction Company consist of one horse and two horse wagons provided with watertight riveted steel tank bodies, provided with a steel cover and having a capacity of 2.12 cubic yards. The tanks are removable from the running gear and it is by this means that the garbage is loaded on cars and transported to the reduction works. A stable, office, and receiving and loading station are maintained by the company in the west-central portion of the city. All garbage is hauled to this point and by means of an electric crane the tank bodies are removed and placed upon flat cars which at the end of each day are transported to the reduction plant.

Final Disposal. The reduction works of the Cincinnati Reduction Company are located upon the north bank of the Ohio River about six miles west of the center of the city and about six miles by rail from the loading station. The immediate surroundings of the plant are not occupied by dwellings and the nearest houses are about 1,000 feet distant. These dwellings are scattered and the nearest community is at Anderson's Ferry, ¼ mile west of the plant. In an easterly direction from the plant there are scattered dwellings along a main road following the

valley of the Ohio River to the city, the outskirts of which are about three miles from the plant.

The reduction works occupy four buildings, namely, a main building, boiler house, drier and storage room, and percolator building. The buildings are all of brick construction but are old and in a dilapidated condition and very poor state of repair. The immediate surroundings of the buildings are maintained in a very untidy condition and the plant as a whole presents an unkempt appearance.

The process used in the handling of the garbage is known as the Detroit Liquid Separating process and was first used at Detroit, Michigan. Recently the process has been modified by the addition of percolators for the recovery of grease from the tankage which was formerly a final product of the process.

The garbage and dead animals are delivered on flat cars at the plant each evening and on the following morning the tank bodies are elevated by an electric traveling crane to the top story of the main building, where they are dumped on the receiving floor. The dead animals, which are delivered in a specially constructed car, are also handled by means of the crane and are placed upon a separate portion of the receiving floor. The receiving floor is provided with drains which carry off a portion of the free water from the garbage, conducting it to open settling tanks located outside the building. The partially drained material is shoveled into digesters, of which there are two rows of nine each extending along each side of the receiving floor. The digesters are each 14 feet deep and 4 feet 6 inches in diameter, and have a capacity of about five tons. The digesters are constructed of ¾-inch riveted steel plates and provided with a flanged opening at the top through which the material is introduced. The garbage is supported on a perforated false bottom, below which steam is introduced. Each digester is filled about two-thirds full with garbage and steam is applied through a grid at the bottom under a pressure of 60 pounds for about six hours. The digesters provided for the rendering of dead animals are of the same construction as the garbage tanks, but 5 feet in diameter and 12 feet deep.

After digestion is completed the liquors are expelled from the mass through the perforated false bottom by steam pressure and conducted into separating tanks on the upper story of the building. The cooked garbage is then removed from the digester by hand and introduced into hydraulic presses in layers between gunny sacks and wooden grids. A pressure of 240 to 350 pounds per square inch is applied and all free water and grease is expelled from the mass. The liquor from the presses runs in open gutters to a collecting tank, from which it is pumped into the separating tanks on the upper story. The layers of pressed tankage or cheeses, as they are called, containing about 40 per cent. of moisture, are carried by chain conveyor to a drier in an adjoining building where the material is thoroughly dried in two Anderson driers. The dry tank-

age is screened by means of revolving 10-mesh screens which receive the discharge from the driers. The tankage is then stored on the floor of the building.

The liquors which are pumped to the settling tank contain a rather large percentage of grease which is separated mechanically by settling. The tanks provided for this purpose are of wood, six in number, each 16 feet long, 5 feet wide and 4 feet 10 inches deep, placed side by side and connected at alternate ends. The tanks are uncovered and the greasy liquor which is often steaming, is permitted to be in direct exposure to the air. The total length of passage of liquid through the tanks is therefore 96 feet, and at the end of the system the grease is skimmed off at the top and the water is drawn off at the bottom. The water flows through a sewer into the settling tanks located outside the building which also receive the liquor drained from the raw garbage. The grease settles in these tanks and a small amount is recovered and returned to the digesters. The liquor flows directly into the Ohio River. The grease from the large settling tanks is stored in a large cylindrical covered steel tank outside the building from which it is drawn off and shipped in tank cars.

The process above described effects a partial recovery of grease from the garbage but a large percentage is left in the tankage.

The average of four analyses of composite samples covering about six months storage of this tankage gave the following results:

Percentage moisture	2.82
Percentage volatile and combustible matter	65.84
Percentage ash	31.34
Calorific value (B T U)	7091.
Percentage ether extract	10.08
Percentage phosphoric acid ($P_2 O_5$)	5.01
Percentage nitrogen (Kjeldahl)	2.94
Percentage potash	0.17

It will be noted that this tankage contains 10 per cent. of grease remaining after the process of separation by pressing. This is equivalent to over 50 per cent. of the original grease content of the raw material.

In order to recover this valuable product an extractor plant has been recently added to the equipment of the reduction works and the tankage is now subjected to percolation with naphtha before it is shipped. In this way practically all of the grease content of the garbage is recovered.

The operation of the Cincinnati Reduction works causes very objectionable odors in the vicinity, and these odors are carried well toward the city by the prevailing westerly winds. An examination of the plant does not reveal the exact location of the sources of these odors, but they rise principally from the leaky condition of the digesters and the fact that the material is almost entirely handled in the open air after digestion when it is in a hot and steaming condition. The discharge of a digester is accompanied by very marked odors, as is the use of the open grease

separating tanks. The driers are, moreover, not connected with a condenser and the vapors are permitted to escape into the atmosphere directly.

Quantity of Garbage Collected. Weekly reports are submitted to the department of public service by the Cincinnati Reduction Company, giving the total number of loads of garbage collected together with the actual weight determined by weighing each load upon its arrival at the loading station. Using these reports as a basis, tables Nos. 47 and 48 have been compiled. It will be seen that a marked increase in the quantities collected occurs during the summer months. The total yearly quantity is also high, and this is due both to the completeness of the collection from households and to the inclusion of market wastes in the quantities reported.

TABLE NO. 47.

QUANTITIES OF GARBAGE COLLECTED.

1908-1909.

	1908				1909			
	Cu. Yds.	Tons.	Cu. Yds. per Capita.	Pounds per Capita.	Cu. Yds.	Tons.	Cu. Yds. per Capita.	Pounds per Capita.
January	3916	2317.8	.0110	13.1	3013	1844.1	.0084	10.3
February	3013	1778.5	.0085	10.0	2913	1808.2	.0081	10.1
March	3029	1862.5	.0085	10.5	2890	1769.0	.0080	9.8
April	3456	2157.7	.0097	12.1	3808	2403.1	.0106	13.4
May	4929	3017.3	.0138	16.9	3748	2372.2	.0104	13.2
June	5631	3438.9	.0158	19.3	4817	3158.6	.0134	17.6
July	4997	3274.9	.0140	18.4	6441	4314.4	.0179	24.0
August	5285	3383.7	.0148	19.0	5964	4215.6	.0166	23.4
September	6269	3849.4	.0176	21.6	7019	4791.8	.0196	26.6
October	4174	2535.5	.0118	14.3	4658	2852.7	.0130	15.9
November	3487	2104.5	.0098	11.5	4198	2622.4	.0117	14.6
December	4032	2518.3	.0113	14.3	4450	2609.6	.0124	14.5
Total	52218	32,239.0	.1466	181.0	53,919	34,761.7	.1500	193.4

TABLE NO. 48.

UNIT QUANTITIES OF GARBAGE, 1907-1909.

	Tons.	Pounds per Capita.	Tons per 1,000 Population.	Average Tons per Working Day.
1907	32,500	185	92.3	104
1908	32,240	181	90.6	103
1909	34,760	193	96.6	111

Cost Data. The first costs of installation of collection and disposal equipment of the Cincinnati Reduction Company were not made available and cannot be presented in this report. The operating costs and receipts from sale of products were likewise withheld.

The total cost to the municipality for the removal of garbage, market wastes and dead animals is represented by the contract price paid to the reduction company. In table No. 49 are presented the total and net costs on this basis.

TABLE NO. 49.

TOTAL AND UNIT COSTS OF COLLECTION AND DISPOSAL OF GARBAGE AND DEAD ANIMALS.

	Total Cost.	Cost per Capita.	Cost per Cu. Yd. Garbage.	Cost per Ton Garbage.
1907	$86,000	$0.244	.....	$2.646
1908	88,000	.247	$1.686	2.724
1909	90,000	.250	1.667	2.590

DEAD ANIMALS.

Previous to 1902, the carcasses of large animals were removed by private rendering companies, who competed in securing them, and paid nominal sums to the owners for their possession. The city removed the smaller animals, but did not engage to any extent in the removal of the larger ones. In 1902 the contract awarded to the Cincinnati Reduction Company provided the exclusive right of that company to care for all dead animals within the city. The company now maintains collecting wagons for this work and daily removes from five to fifteen horses and cattle and a greater number of smaller animals. They are loaded upon cars with the garbage and handled at the reduction plant as has been described. It has been found impossible to secure data giving the number of dead animals removed or the cost of collection.

RUBBISH AND ASHES.

Municipal collection of rubbish and ashes was begun in 1865, combined with the collection of garbage. In 1897, as has been described, separation of the wastes took place, but since that time no radical change has been made in the collection of this class of material. The department has, however, developed to a great extent with the growth of the city and is now in a high state of efficiency.

Present Methods.

The rubbish-ashes collection department is under the street cleaning department, being in charge of the street cleaning superintendent. Under him are two assistant superintendents and nine district superintendents. All laborers in the department are appointed by the superintendent, and it is claimed that political tendencies are disregarded. The department as a whole is efficiently organized and the positions are filled by capable men, experienced in their particular line of work.

Character of Territory from which Collection is Made. Rubbish and ashes are collected from all sections within the city. There are nine collection districts, located to suit topographical conditions. The districts are irregular in shape and vary in population and area. Five of the districts are in purely residential sections, while four of them are of smaller area and cover the business and mixed sections. In all sections rubbish is collected at least once each week. In certain parts of the city, especially the more congested districts, collections are made two or three times each week.

Equipment for Collection. The city owns all of the equipment used for rubbish and ashes collection. The wagons used are of a special type made to facilitate dumping of the material at the edge of steep slopes. To this end the body of the wagon is constructed to tip backward over the rear axle and the contents are quickly dumped in this manner. The wagons used are one-horse and two-horse, having capacities of 2.4, 2.56 and 4 cubic yards. The wagons are all made by the repair department of the street cleaning department and cost somewhat less than the special types which are sold by manufacturers.

The department maintains seven stables located in various portions of the city. Two main stables are located in the central portion of the city and accommodate the principal equipment of the department, as well as that of the street cleaning department. The other stables are small, accommodating equipment required in the outlying districts of the city. It has been found advantageous to maintain these smaller stables to reduce the distance to be covered by the teams in reaching and leaving their districts.

Methods of Collection. Stringent rules have been passed by the city in regard to the duties of the householders in facilitating the collection of rubbish and ashes. These apply principally to the exclusion of garbage from the material, the provision of proper receptacles and placing of them within easy distance for the collector. The enforcement of these rules has been found very difficult and their observance is principally due to the education of the people with the growth and development of the collection system. Complaints against the department for neglect in collection are of rare occurrence and an almost exact schedule is followed out by the more experienced collectors.

Final Disposal. Since the establishment of the rubbish and ashes department the material has always been disposed of by dumping on land. The valley of Mill Creek near the central portion of the city has offered the most convenient means for disposal, and here the greater portion of the material collected is dumped. The department has already recovered in this way hundreds of acres of land which is used for lumber yards, railroad yards and buildings of light construction. The lowlands in the valley are rapidly filling and at the present time it is not thought that available space will be had for more than fifteen years. The dumping grounds are all privately owned and in some cases the city has received a fee for filling and improving the land.

All the rubbish and ashes collected from the main central portion of the city are disposed of in the Mill Creek valley. The material collected in the residential portions of the highlands is, however, disposed of by dumping at points in depression and gullies in the hills. These dumps are as a rule very much smaller than the dumps of Mill Creek valley and are more rapidly filled. The Mill Creek valley dumps are in a section of the city given over to manufacturing and railroad use, and the presence of the dumps, therefore, is not so objectionable as would otherwise be the case. Those in the highlands are, however, often located in close proximity to residential districts and are often the cause of considerable complaint due to odors which emanate from them, as well as general unsightliness caused by dust and rubbish blown about by the wind.

All of the dumps are managed according to the same plan, namely, by carrying out the surface on a level, thus allowing a steep embankment over which the material may be dumped. With care the appearance of the dump may be made presentable, but this is entirely dependent upon the attention of the man in charge. Some of the dumps are level and clean at the surface, while others are littered with all sorts of rubbish, which is likely to be scattered about the neighborhood. The city maintains one man on each of the larger dumps and gives some attention to all of the dumps used. Picking of rubbish is permitted and is the common practice at each of the dumps.

Aside from the unsightliness of the neighborhood due to material scattered from the dumping grounds, the dumps have become extremely objectionable on account of fires which originate accidentally and which are very difficult to extinguish. The odors thus created are perhaps the most serious causes for complaint.

Quantity of Material Collected. In table No. 50 are given records of quantities of material collected monthly during 1908 and 1909, and in table No. 51 are given unit quantities collected yearly from 1907 to 1909. It will be seen that the maximum collection occurs during the winter months of each year, when the production of household ashes

is highest. The tonnage given in the tables is calculated from data s
cured during the studies from which the weight per cubic yard w
estimated. The yearly records indicate a decrease in the quantity
rubbish and ashes collected during the succeeding years from 1907
1909. No explanation for this is made.

TABLE NO. 50.

QUANTITIES OF RUBBISH-ASHES COLLECTED.

	1908				1909			
	Cu. Yds.	Tons.	Cu. Yds. per Capita.	Pounds per Capita.	Cu. Yds.	Tons.	Cu. Yds. per Capita.	Pounds per
January	27,529	12,870	.0773	72.3	23,333	10,908	.0648	6
February	24,883	11,633	.0700	65.4	21,479	10,041	.0597	5
March	21,999	10,285	.0618	57.8	23,040	10,721	.0640	5
April	19,083	6,507	.0535	36.5	20,986	7,156	.0582	3
May	16,862	5,750	.0473	32.3	17,559	5,988	.0487	3
June	16,358	5,578	.0460	31.3	15,489	5,282	.0430	2
July	15,163	5,170	.0426	29.0	14,424	4,919	.0400	2
August	14,552	4,962	.0409	27.9	13,443	4,584	.0373	2
September	14,210	4,846	.0399	27.2	13,685	4,667	.0380	2
October	16,006	5,453	.0450	30.6	15,916	5,427	.0443	3
November	19,034	6,491	.0535	36.5	18,300	6,240	.0510	3
December	24,139	11,285	.0678	63.4	24,980	11,678	.0694	6
Total	229,818	90,830	.6455	510	222,634	87,611	.6184	

TABLE NO. 51.

UNIT QUANTITIES OF RUBBISH-ASHES.

1907-1909.

	Cu. Yds.	Tons.	Cu. Yds. per 1,000 Population.	Tons per 1,000 Population.	Av. Cu. Yds. per Working Day.	Av. Tons per
1907	235,370	92,618	668.7	263.0	752	29
1908	229,818	90,830	645.5	255.1	734	29
1909	222,634	87,611	618.4	243.4	711	28

Character of Rubbish and Ashes. In the main portion of this rep
are given the results of the study of character of rubbish and ashes

Cincinnati. The material does not differ in appearance from that observed in the other cities of the state, excepting during the winter season when the preponderance of household ashes is noted. The admixture of garbage in the material is more noticeable at Cincinnati than in other cities, and it is only with the greatest difficulty that this tendency is being overcome by the collection department.

Cost Data. The total cost of collection of rubbish and ashes for 1907, 1908, and 1909, the earnings from filling and sale of rubbish, and the net costs are given in table No. 52. The total costs include actual expenditures for labor, stable maintenance and repairs, but do not include supervision, overhead expense or fixed charges. It will be noted that the unit costs given in table No. 53 are regular and indicate a constancy in the efficiency of the department.

TABLE NO. 52.

COST OF COLLECTION OF RUBBISH AND ASHES.

	Total Cost.	Earnings.	Net Cost.
1907	$126,051.68	$2,350.15	$123,701.53
1908	121,338.25	1,930.65	119,407.60
1909	116,631.68	1.738.20	114.893.48

TABLE NO. 53.

UNIT COST OF COLLECTION OF RUBBISH AND ASHES.

	Net Cost.	Cost per Capita.	Cost per Cu. Yd.	Cost per Ton.
1907	$123,701.53	0.351	0.525	1.33
1908	119,407.60	0.335	0.520	1.32
1909	114,893.48	0.319	0.510	1.32

STREET CLEANING.

Municipal street cleaning was begun at Cincinnati in 1865, at the same time collection of garbage and other wastes was inaugurated. Previous to that time the work was done by contractors paid by the city. The department has since that time undergone an extensive development, but no radical changes in its organization or method of operation have taken place.

Present Methods.

The street cleaning department is in charge of a superintendent, who also supervises the work of the rubbish and ashes department. The work of the two departments is carried on by the same assistant superintendents and clerical force, but a separate corps of laborers and foremen are employed. All of the streets within the city are cleaned, the frequency varying with the character of the locality. The downtown business portion is cleaned each night, while the outlying residential portions are cleaned weekly during the greater portion of the year.

Equipment. The equipment of the department for street cleaning includes 47 flushing machines, 5 sprinkling wagons, 14 machine brooms, 70 white-wing outfits, dump wagons, and other miscellaneous tools for the work. The flushers are of the St. Louis and Sanitary type. This portion of the equipment is constantly being increased to make possible the extension of the flushing method of cleaning. The machine brooms are principally old equipment of the department, but are maintained in good working condition and used in connection with the flushers. The white-wing outfits consist of patrol carts, cans, shovels, scrapers and brooms.

All of the street cleaning equipment, including horses and mules, is maintained at the same stables used for the rubbish and ashes collection equipment. At the main stable there is also kept a repair and manufacturing department, where all dump wagons, harness, brooms, etc., are made and repaired.

Methods of Street Cleaning. Previous to 1907 cleaning by machine sweepers was the principal method of street cleaning used at Cincinnati. Since that time, however, flushing and hand cleaning have developed into the most important methods and the machine sweeping method has been practically abandoned. The flushing method used at Cincinnati is, however, really a combination of the flushing and machine sweeping methods, as both flushers and machine sweepers are used. A crew for this method of cleaning consists of four flushers and three sweepers. The flushing machines apply water to the street, loosening the dirt, and are immediately followed by the machine sweepers, which assist in carrying the mud and water into the gutters.

The hand cleaning method is used to a greater extent than the flushing method, and the larger percentage of the total area is cleaned by this method. The material is swept or scraped from the surface by hand and placed in cans provided for this purpose.

In table No. 54 are given the areas cleaned by the various methods during 1907, 1908 and 1909. It will be seen that there has taken place a gradual increase in the percentage of the total area cleaned by flushing, and that barring a small amount in 1908 the machine sweeping

method has not been used. It is also of interest to note the decided increase in the total areas cleaned during each succeeding year.

TABLE NO. 54.

AREAS CLEANED BY VARIOUS METHODS.

Method.	1097		1908		1909	
	Squares (10,000 sq. ft.)	Per Cent.	Squares (10,000 sq. ft.)	Per Cent.	Squares (10,000 sq. ft.)	Per Cent.
Flushing	50,190	30.8	97,355	35.9	126,439	39.4
Hand Cleaning	112,571	69.2	168,924	62.4	195,144	60.6
Machine Sweepers	none	.....	4,637	1.7	none	.....
Total	162,761	100.0	270,916	100.0	321,583	100.0

In table No. 55 are presented comparisons in areas cleaned and material removed for various years. It will be noted that with the development of the flushing and hand cleaning methods the quantity of material removed per great square has reduced. This is due principally to two reasons. Flushing tends to cause a large quantity of the finer material to enter the sewers with the water. Also the increased areas cleaned indicate more frequent cleaning, which would, of course, result in a smaller quantity of material removed per unit area.

TABLE NO. 55.

AREAS CLEANED AND MATERIAL REMOVED.

1907-1909.

	Great Squares Cleaned.	Cu. Yds. Dirt Removed.	Cu. Yds. per Great Square.
1907	162,761	90,597	.556
1908	270,916	148,867	.549
1909	321,583	129,359	.403

Final Disposal. All the material removed from the streets is disposed of by dumping at the various rubbish dumps located throughout the city. The material owing to its nature is used principally for surfacing the dumps and in no case has it been found to create a nuisance.

Snow Removal. For snow removal no special equipment is maintained by the city, but when required the entire street cleaning department is devoted to this work. The snow is removed from the main central portion of the city and disposed of by dumping into the main sewers discharging into the Ohio River and Mill Creek. During 1909 33,800 cubic yards of snow were removed and disposed of at a cost of 39¾ cents per cubic yard.

Quantities of Street Cleanings. In table No. 56 are given the monthly quantities of street and catch basin cleanings for 1907, 1908 and 1909. The increased quantities collected during the months from March to November indicate the period of greatest activity in street cleaning.

TABLE NO. 56.

QUANTITIES OF STREET AND CATCH BASIN CLEANINGS COLLECTED.

Cubic Yards. 1907, 1908, 1909.

	1907	1908		1909	
	Street Cleanings.	Street Cleanings.	Catch Basin Cleanings.	Street Cleanings	Catch Basin Cleanings.
January	4,769	5,845	683	6,865	1,005
February	4,772	8,816	714	6,852	1,396
March	12,687	17,888	947	12,533	1,793
April	8,953	14,056	1,030	12,173	1,741
May	7,679	12,824	1,112	11,378	1,630
June	9,574	13,077	1,305	12,154	1,648
July	8,627	12,818	1,453	11,304	1,735
August	8,348	13,433	1,808	12,458	1,658
September	8,254	14,050	1,500	12,127	1,566
October	8,807	14,733	1,796	13,760	1,758
November	5,624	11,181	1,471	11,520	1,604
December	2,503	10,146	1,650	6,235	1,238
Total	90,597	148,867	15,469	129,359	18,772

Cost Data. The cost of street cleaning for 1907, 1908 and 1909, together with unit costs of same are presented in table No. 57. The expenditures for street cleaning have been regulated by the appropriations granted for this purpose, and during recent years there has taken place a marked increase in the amount of money provided. This has

made possible more thorough work and the results indicate that a greater efficiency has been obtained.

The total costs in table No. 57 include the labor expense and a proportionate amount of the expense for stable maintenance and repairs. They do not include overhead expense and fixed charges. It will be seen that the improved methods of street cleaning have accomplished a reduction in the cost per unit area.

TABLE NO. 57.

COST OF STREET CLEANING.

	Total Cost.	Cost per Capita.	Cost per Cu. Yd. Dirt Removed.	Cost per Great Square.
1907	$159,556	$0.452	$1.76	$0.980
1908	210,846	.592	1.42	.775
1909	229,187	.636	1.77	.713

CATCH BASIN CLEANING.

The cleaning of catch basins was until 1908 carried on by the city engineering department, which department has general supervision over the sewerage of the city. In 1908 the work was transferred to the street cleaning department. This was done on account of the similarity of the work of street and catch basin cleaning, and was due largely also to the growth of the flushing method of street cleaning, which had the effect of increasing greatly the necessity of catch basin cleaning.

The work is carried on by a corp of 35 laborers in charge of a foreman. Districts are laid out and the catch basins are regularly cleaned in each, particularly in those where flushing is frequent. Special tools and equipment, including tight dump wagons, are used. The extent of this work is indicated by the number of basins cleaned. In 1908 and 1909 there were respectively 11,178 and 20,228 catch basins and inlets cleaned by the department. The material removed is disposed of by dumping in the same manner as the street cleanings. It is of very similar character, consisting largely of siliceous matter and manure, and is no more objectionable than street sweepings.

Cost Data. The cost of catch basin cleaning for 1908 and 1909 is given in table No. 58. This total cost includes labor and stable expense, but does not include overhead expense or fixed charges.

TABLE NO. 58.

COST OF CATCH BASIN CLEANING.

	Total Cost.	Cost per Basin.	No. Basins and Inlets Cleaned.
1908	$24,036	$2.15	11,178
1909	27,596	1.36	20,228

NIGHT SOIL.

This class of municipal waste has always been collected and disposed of privately. The work is, however, under municipal supervision, and the time during which it may be performed as well as the method of disposal are regulated.

A number of contractors licensed by the city are engaged in the work. City rules provide that the material be collected in watertight wagons between the hours of 10 p. m. and 5 a. m. and disposed of by dumping into the sewers at points designated by city authorities. These points are generally at manholes in main sewers discharging into the Ohio River or Mill Creek.

Night soil removal is satisfactorily accomplished by this means and has given rise to no complaint.

COLUMBUS.

The city of Columbus is located in the central portion of Ohio at the confluence of the Scioto and Olentangy rivers. The area within the corporation limits is 20.6 square miles. The topography within the city is generally flat and only the valleys of the streams present any marked difference in elevation. In connection with the topography it may be noted that in no portion of the city is the haul of collection wagons made difficult. The present population of the city is 181,511. Since 1880 the population growth has been very great as shown by the following table:

Year.	*Population.*	*Percentage Inc. During Last Decade.*
1880	51,647	....
1890	88,150	71.6
1900	125,560	42.4
1910	181,511	44.6

The present population of the entire city represents an average of 8800 per square mile, and practically all portions within the corporation limits are built up. Owing to its favorable railroad and shipping facilities, Columbus is growing to be an important manufacturing center and as is the case in cities of this character, the population is made up quite largely of people of the middle class. The percentage of foreign population is low.

In municipal improvements the city has been very progressive, and its development in this line has been greater perhaps than that of any other city of its size in the country. A water supply which was previously objectionable was converted into one of entirely satisfactory quality by the installation of purification works in 1908. Nuisances arising from the discharge of sewage into the Scioto River were eliminated by the construction of purification works which were placed in operation in the fall of 1908. The most recent municipal improvement and the one of perhaps greatest interest is the improved system of garbage collection and disposal installed by the city in 1910. The city maintains a street cleaning department and at present is contemplating municipal collection and disposel of other classes of waste consisting of rubbish, ashes, and manure. When this important step has been accomplished, the collection and disposal of city wastes of Columbus should compare favorably with the development in some of the larger cities of the country, and the general sanitation should be greatly improved.

The collection and disposal of city wastes and the cleaning of streets are under the general supervision of the department of public service,

and the work which is at present carried on is placed under two departments, namely, the garbage department and the street cleaning department. The collection of rubbish and ashes, should such be inaugurated by the city, will be placed under the supervision of the garbage department.

GARBAGE.

Previous to 1896 there was no organization in the collection and disposal of the garbage of the city. Independent licensed scavengers and to a large extent farmers from the surrounding country were engaged in this work, and the cost of removal was entirely upon the householder. Certain portions of the city, particularly the business portion, received satisfactory service, but the larger part of the city was neglected and as a result unsatisfactory conditions prevailed. The waste material removed by the farmers was disposed of by feeding to hogs, and that collected by scavengers was disposed of largely by dumping at the outskirts of the city. This created nuisances in the vicinity of the dumping places and caused much complaint from nearby residents.

In 1896 the city entered into a contract with the Columbus Sanitary Works Company for the collection and disposal of garbage and dead animals. This contract was in force ten years, expiring in April, 1906. The company collected the material in steel tank wagon bodies which were loaded upon flat cars at a station in the central portion of the city and shipped by rail to Bannon, a station on the T. & O. C. Railroad immediately west of Alum Creek and about four and one-half miles southeast of the State Capitol. Dead animals were hauled directly to the plant in large wagons built for the purpose. At Bannon the company operated a reduction plant where the garbage and dead animals were handled and saleable products recovered and sold.

By the terms of its contract the company received a flat rate of $15,800 per year. No increase in this rate was provided to allow for the natural increase in the quantity of material to be collected resulting from the growth of the city. During the early years of the contract the price paid to the company was satisfactory to both parties and the contractor was enabled to give efficient collection service. With the growth of the population, however, the contractor could not without serious financial loss remove completely the garbage produced in the city, and consequently the work was very inefficiently performed. During the later years of the contract the incompleteness of the collection by the company encouraged farmers to again collect garbage from available sources within the city, and this was permitted as it offered a partial means of relieving the company.

In the early portion of 1906, before the expiration of the contract with the Sanitary Works company, John H. Gregory, who was then principal assistant engineer of the city engineering department, sub-

mitted a report of a study of the waste disposal problem of the city to determine the logical method of procedure to be adopted. The summary of his report embodied the following suggestions:

"That the present practice of collecting and disposing of street sweepings by dumping on low land be continued.

That a municipal service for the collection and disposal of domestic ashes be postponed.

That the garbage, rubbish and dead animals be collected by the city by its own employees, and that sufficient equipment and stable accommodations for the purpose be provided.

That the city construct and operate a crematory and that the garbage, rubbish and dead animals be cremated therein.

That a municipal service for the collection and removal of stable manure is not desirable or warranted.

That night soil should not be collected, but should be disposed of at the city's expeuse."

Following this report there was considerable controversy as to whether the city should install a crematory or a reduction plant for the final disposal of garbage, and it was therefore decided to delay the improvements until the relative merits of the two systems could be demonstrated.

At the expiration of the contract of the Sanitary Works company in April, 1906, the city took over the collection equipment of that company and inaugurated municipal collection. To provide for temporary means of disposal, a tract of land southwest of the city was purchased and used as a burial ground. The property known as the English farm had an area of about 77 acres covering low land immediately west of the Scioto River and about two and one-half miles from the central portion of the city. It will be seen that the length of haul was excessive, the average being between three and four miles. This method of disposal was practiced until July, 1910, when the municipal reduction plant was placed in operation. Except during the year 1908, when the city board of health took charge of the work of the garbage department, it has been under the general supervision of the department of public service.

In burying the garbage, trenches were dug from one to two feet deep, about seven feet wide, and of indefinite length; the garbage placed at a depth of about two feet and covered with earth removed from the adjacent trench. By this means it will be seen that the material was covered by a layer of earth varying from one to two feet in thickness, depending upon the depth of the adjacent trench. The garbage was usually covered a few hours after dumping and was never left exposed to the air for a period greater than twenty-four hours. No objectionable odors were caused by this method of disposal and no complaint was registered against it. After burying, the garbage slowly under-

goes putrefaction and finally occupies a layer one-fifth to one-third its original thickness. In the spring of 1909 several holes were dug to uncover garbage which had been buried for different periods with a view to discovering to what extent putrefaction had been completed. The following was a result of the observations:

Time Buried.	*Condition.*
6 to 9 months.....	In very high state of putrefaction. Objectionable odor. Constituents readily distinguishable.
17 "	In somewhat less state of putrefaction; still readily distinguishable.
20 "	Still decomposing and of foul odor. Character more or less distinguishable.
30 "	Material inocuous, resembling humus matter and having a slight musty odor, very faintly distinguishable.

It will be seen from these observations that the garbage was not rendered entirely stable until two and one-half years after its burial, but at this time it was found to be in such condition that the land was again ready to be used for burial.

While burial was being employed as a temporary means of disposal, the question of the method of final disposal to be adopted by the city was argued by adherents of both reduction and cremation. It was finally decided that the reduction method be adopted and that a plant be constructed according to plans to be drawn by an engineer engaged by the city for that purpose. In connection with the building of the reduction plant, which was completed in 1910, improvements were also made in the collection system and an entire new equipment consisting of wagons, teams, stables, loading station, and cars for transportation to the reduction plant, was added. The reorganized collection system and the reduction plant were placed in service in July 1910 and have given satisfactory service since that time.

Present Methods.

Organization. The collection and disposal of garbage are under the general supervision of the director of public service and under him are two superintendents, one having charge of the collection and the other having charge of the final disposal.

The duties of the superintendent of the collection department are to have general charge of the collection work, the laying out of districts, investigation of complaints, and all other questions which arise, and to oversee the care and work of the loading station, stables and equipment. Under him the details of the work are cared for by a stable foreman and an inspector, who have immediate charge of the men employed in the department. The laborers and drivers are appointed at the discretion of the superintendent and their positions are not af-

fected by their political tendencies. Aside from the superintendent, 28 men are employed, and the total daily pay roll of the collection department is $64.

The superintendent of garbage disposal is in full charge of the operation of the reduction plant. The present incumbent is a mechanical engineer and an expert in the design and operation of reduction works, and previous to taking up his present duties was engaged as engineer of design and construction of the Columbus plant. The details of the work at the plant are in the immediate charge of an assistant superintendent and master mechanic, who under the direction of the superintendent are rapidly becoming proficient. Aside from the superintendent there are 16 men employed at the plant, and the daily pay roll amounts to $40. The same conditions of employment govern the selection of men at the reduction plant as in the collection department, and political tendencies are not regarded.

Character of Territory from Which Collections are Made. Garbage is collected from all of the territory lying within the corporation limits of the city, but from no points outside. The total area of this territory as has been stated, is 20.6 square miles. The collection districts are bounded by indefinite limits and are frequently changed by the superintendent to meet the varying conditions occurring during different portions of the year. Due to a material reduction in the length of haul, it has been found possible to decrease the number of collection districts by adding to the area to be covered by each wagon, and there are now only 17 districts, each served by one wagon, instead of 22 to 25 which existed when the garbage was disposed of by burial upon the English farm. The garbage collected is almost entirely of residential origin, and up to the present time only a small quantity has been collected from hotels and large restaurants. This class of garbage is removed to a large extent by a rendering company engaged in soap manufacture, but will no doubt be cared for by the city as soon as the city will also agree to remove rubbish and ashes without expense to the hotels. The frequency of collection varies somewhat in different portions of the city. In the central business portions collections are made daily throughout the year, and in the residential sections it is aimed to make collections weekly. This is accomplished in all but the remote and thinly populated districts in the outskirts where somewhat less frequency of collection obtains. The average length of haul under present conditions cannot be stated with any degree of accuracy and only a rough approximation can be given. The maximum haul is about four miles and the minimum haul is not over one-half mile. The larger portion of the garbage must be hauled at least one and three-fourths miles, and on the basis of these figures the average length of haul is in the neighborhood of two miles.

Equipment for Collection. The equipment of the collection depart-

ment is entirely new, having been placed in service but recently. Thirty-four wagons are owned by the city, and as but 15 to 20 of these are regularly used, the wagon equipment is practically in duplicate. The wagons are each drawn by a team of two horses, and on the whole this method has been found more satisfactory than the use of a single animal. The wagons are patterned after those used in Cleveland and are of very similar construction. The body of the wagon is a steel tank, 4 feet in width, 21 inches deep, 10 feet 10 inches in length at the top and 8 feet 5 inches in length at the bottom. The capacity when loaded level is about 2.5 cubic yards. The wagon body is covered by oiled canvas supported on an arched steel frame. The first cost of the wagons was $203 each.

The type of wagon used at Columbus has been found satisfactory both there and at Cleveland for several reasons, the principal ones of which are the facility of dumping and the avoidance of noise caused by steel covers, so common in the usual type of collection wagon.

In addition to the garbage collection wagons, the department owns and operates a one horse ambulance and two wagons for the removal of smaller animals.

The collection department at present owns 50 horses, the greater number of which are used in garbage collection. The horses were purchased in the open market with funds saved by the superintendent from those appropriated for collection, and cost on an average $208 each.

In order to facilitate the work of the superintendent and inspector, they are provided with conveyances. The superintendent uses a motor cycle by means of which he can cover a large territory in a short time, and the inspector is furnished with a horse and buggy.

The city stable for the garbage collection department is located in the southwest-central portion of the city about three-fourths of a mile from the central portion of the city. It was built in 1910 and its total cost was $40,000. It is located on a tract of land owned by the city with an area of six acres, which is also occupied by the receiving station. The stable is of brick, concrete and steel construction and is fireproof on its lower floor. The building is 200 feet in length, 60 feet in width, and has an ultimate capacity of 108 stalls, 70 of which have been already built. The stalls are all located on the lower floor. The upper floor is provided for storage of feed and also contains the office of the superintendent as well as a properly designed toilet room for the convenience of the men. This room also includes shower baths, a feature which is uncommon in such installations. At present the collection wagons are stored in the yard near the stable. It is planned, however, to construct a wagon shed in order that the wagons may be protected from the weather when not in use.

The receiving station, where the garbage is transferred from the collection wagons to cars for shipment to the reduction plant, is located

on the same lot with the stable. The building is of concrete and brick construction and is arranged with two floors, the upper one of which is reached by means of an inclined roadway. Here the wagons are driven and by means of a hand operated chain hoist the wagon body is tilted and the garbage dumped into cars which are drawn into the building on a siding at grade level. The lower floor of the building is occupied by two rooms, one of which was designed as a blacksmith and repair shop, the other as a place for the washing of the wagons.

In dumping the wagons they are backed against a curbing and easily elevated by means of a hoist, and the material is quickly and completely transferred to the car below. The design is such that the load falls in the middle of the car, and therefore a minimum amount of labor in leveling the garbage in the car is required.

The freight cars for the transportation of the garbage are patterned after those used at Cleveland and are of practically the same construction. Four cars are owned by the city, and under present conditions provide ample capacity as two may be at the receiving station and two at the reduction plant at all times. The car is built entirely of steel and consists of a large semi-circular tank mounted on rollers and trunnions. The car is dumped by revolving in either direction on the longitudinal axis, suitable rolling bearings being provided for the purpose. The capacity of each car is 40 tons, and they are of such size as to accommodate 54 cubic yards. The cost of the cars was $1890 each, which compares favorably with the price paid at Cleveland, of $2450 each.

Method of Collection. In order to facilitate the work of collection, rules and regulations have been adopted by the collection department. These relate principally to the provision of proper receptacles and the exclusion of rubbish from the material. The rules have been found very difficult to enforce and are violated quite generally. The receptacles commonly used in the residential districts of the better class are watertight, covered, galvanized iron cans of 10 to 20 gallons capacity. In the poorer residential districts, however, the receptacles are usually of an unsuitable type. Here, old tubs, buckets, wash boilers, boxes, and lard cans are commonly used. The use of such receptacles, needless to say, increases greatly the work of the collection department.

Final Disposal. The municipal reduction plant is located about four miles south of the center of the city and about one mile from the corporation line. It is situated on a tract of two acres lying immediately west of the Scioto River and adjacent to the sewage purification works. The location for both the sewage and garbage disposal plants was selected because of its remoteness from habitations, and at present no dwellings are situated within three-fourths of a mile of the plant.

The reduction works were constructed in 1910 and consist of four buildings; namely, a green garbage building, 90 feet by 40 feet in plan;

a main building in which the machinery is located, 162 feet by 76 feet in plan; an office building; and a stable. There is soon to be added a separate building to house an extractor plant, and this will be located adjacent to the main building. All of the buildings are entirely new and present a very neat appearance. They are of concrete, steel and brick construction and are fireproof. Their surroundings are maintained in a tidy condition, walks and lawns being provided.

The green garbage building is provided to receive the material as it is unloaded from the cars. The garbage cars are drawn into the building on a siding which extends through it. The siding is at such elevation that upon tilting the body of the car the material is discharged by gravity on to a dumping floor below the tracks. The dumping floor is constructed of concrete and is sloped to a drain by means of which the free water is removed from the material. This free water is conducted into a sump or well, from which it is pumped for future treatment at the plant. A portion of the rubbish is picked from the garbage by hand and disposed of by dumping near the plant. The garbage is shoveled into a 24-inch scraper conveyor which extends the full length of the dumping floor, and this conveyor carries the material to the main building, discharging it at the top story. Connected to this conveyor are swiveled spouts, by means of which the garbage is conducted into the digesters.

There are eight digesters arranged in two nests of four each. The digesters are each 7 feet in diameter by 14 feet deep and are constructed of 5/8 inch riveted steel plate. The capacity of each digester is 12 tons. The inner lining is of cement and tile 1-1/2 inches in thickness. The inlet is an 18-inch circular opening at the top, the outlet being 16 inches in diameter at the bottom and fitted with a gate valve. Steam for cooking the material is conducted at the bottom through oppositely placed pipe connections, and during cooking the steam is allowed to escape at the top through a ¼-inch by-pass, and this vapor is conducted to a condenser to avoid the production of odors.

Each nest of four digesters discharges directly downward into a receiving hopper from which the material is fed to the presses placed below the hoppers and on the ground floor of the building. The vapors from the hot tankage in the receiving hoppers are conducted to a condenser which is trapped by a vapor tight steel hot well. Any odors escaping the condensers are conducted to the boiler fires. The presses are of the continuous roller type manufactured by the Kutztown Foundry & Machine Company of Philadelphia. Each press is enclosed with a vapor-tight cast iron housing about 28 feet long, 3 feet wide, and 7 feet high. The material after it passes the presses is rather dry in appearance, containing about 40 per cent moisture, and has no very objectionable odor. It will be noted that at this point the garbage is first exposed to the air since its introduction into the digesters. It is carried by a

scraper conveyor from the presses to the second story of the drying department, where it is fed downwards into a revolving cylindrical steam jacketed drier. The material is fed through this drier continuously, and upon its discharge is again conveyed to the second story of the building and screened.

The water and grease from the roller presses flow through a covered conduit into catch basins located below the floor of the grease separating room. From these catch basins the liquors are pumped into the separating tanks. These are six in number, each being 7 feet in diameter by 12 feet deep, constructed of riveted steel plates, entirely enclosed from air, and connected at the top. The grease is drawn off from the top of the last tank and stored for sale. The liquor from which the grease is separated carries with it a large amount of floating and suspended solids which collect at the top and bottom of the separating tanks. This material is removed from the tanks by a magma pump which discharges it into a storage tank from which it is drawn and filter pressed. The liquids flow to the catch basin, and the solids are conveyed to the drying room. The tank water is drawn from the last of the grease separating tanks and pumped to a triple-effect evaporator for the recovery of what solids it holds in solution as well as to provide for its proper disposal. By passage through the evaporator the liquid is converted from a specific gravity of 5 degrees to 25 degrees Baumé. The concentrated liquor, or so-called stick, is pumped by a magma pump to a storage tank in the drying department.

The tankage, which has been passed through a continuous cylindrical drier and screen, is introduced into vacuum or mixing driers of which there are two. Upon introduction into the driers, the concentrated syrup or stick is added to the tankage and the mixture is dried completely. It is then conveyed to the third floor where it is stored for shipment. The addition of the stick produces a high grade of tankage in which there is but a small amount of fluffy or light fibrous material. This tankage according to analyses made by the chemist of the sewage purification works has approximately the following composition:

Percentage	moisture	7.0
"	ether extract	9.0
"	ammonia ($N H_3$)	3.4
"	bone phosphate of lime ($Ca_3 P_2O_8$)	5.5

It will be noted that the grease content remaining in the tankage after the separation by the pressing process is 9 per cent. It is in order to recover this valuable product that the naphtha extraction plant is to be installed. With the addition of a grease extraction plant the tankage will be conveyed from the storage room to the percolators and after the grease has been recovered, returned again for storage and shipment.

The boiler plant consists of three horizontal tubular boilers, 78

inches in diameter by 20 feet long. All electric power for driving the motors direct connected to the conveyors and presses is furnished by a municipal lighting plant.

From the standpoint of the prevention of a nuisance incidental to garbage disposal, the Columbus plant represents the most perfect development in the reduction process which has been reached. No objectionable liquid wastes are produced as all liquors are evaporated and only condensation water is discharged from the plant. The production of odors is minimized by keeping the garbage enclosed from the air while it is in a hot, steaming and odorous condition. The condensation of foul vapors from the digesters, presses, and driers, prevents contamination of the air by noxious odors. Although no serious complaints have been made, the plant cannot be said to be inodorous, and faint odors are noticed at a distance of one-fourth mile or more in the direction of the wind.

Quantity of Garbage. The quantities of garbage collected as obtained from records of the collection department, are given for each month during 1908 and 1909 in table No. 59. The tonnage is calculated from data secured during the experimental studies herein described. A comparison of the quantities collected during the two years shows a marked increase in 1909 over the collection of 1908. This is due to energy on the part of the department to make more frequent and complete collections. It will be seen that during the summer months the quantities collected are very much greater than at other seasons of the year.

TABLE NO. 59.

QUANTITIES OF GARBAGE COLLECTED.

1908-1909.

	1908				1909			
	Cu. Yds.	Tons.*	Cu. Yds. per Capita.	Pounds per Capita.	Cu. Yds.	Tons.*	Cu. Yds. per Capita.	Pounds per Capita.
January	1,552	742	.0091	8.7	1,738	832	.0099	9.4
February	1,574	752	.0093	8.8	1,566	749	.0089	8.6
March	1,482	708	.0087	8.4	1,734	828	.0099	9.4
April	1,920	1,176	.0113	13.8	2,212	1,355	.0126	15.4
May	1,670	1,023	.0098	12.0	1,936	1,185	.0110	13.4
June	1,626	997	.0096	11.8	1,994	1,221	.0113	13.8
July	2,176	1,360	.0128	16.0	2,692	1,682	.0153	19.2
August	2,384	1,490	.0140	17.6	2,910	1,818	.0165	20.6
September	2,318	1,450	.0136	17.0	3,856	2,402	.0219	27.4
October	2,374	1,494	.0140	17.6	2,384	1,500	.0136	17.0
November	1,586	998	.0093	11.8	2,088	1,313	.0119	15.0
December	2,090	1,315	.0123	15.4	2,588	1,628	.0147	18.4
Total	22,752	13,505	.1338	158.9	27,698	16,513	.1575	187.8

* Weight of garbage calculated from the following data:

Average weight per cubic yard.

Jan., Feb., Mar.	957 pounds
Apr., May, June	1,226 pounds
July, Aug., Sept.	1,250 pounds
Oct., Nov., Dec.	1,258 pounds

Cost Data. The improvements in garbage collection and disposal of 1910 included entire new equipment in both departments and all old equipment and supplies were discarded. This old equipment was in a very poor state of repair and was practically worthless for use in connection with the improved system.

In table No. 60 are given itemized costs for the improvements.

TABLE NO. 60.

COST OF IMPROVEMENTS IN GARBAGE COLLECTION AND DISPOSAL — 1910.

Collection.

Site for loading station, night soil station, dog pound and stables	$10,136.40
Loading station	14,101.40
Stable	39,046.55

Collection — Concluded.		
Trestle and driveway	2,153.10	
Grading, etc.	2,379.54	
Collection wagons	7,151.10	
Cars	7,564.00	
Railroad sidings	3,161.60	
Horses	10,000.00	
		$95,693.93
Disposal.		
Levee	$9,711.72	
Buildings, grading, etc.	81,267.05	
Reduction machinery	59,866.00	
Power equipment	21,356.70	
Elevators and conveyors	9,316.22	
Railroad sidings	3,342.80	
Wiring	3,670.99	
Non-conducting covering	1,010.75	
		189,542.23
Miscellaneous.		
Office expense and advertising	$1,401.18	
Engineering	16,143.48	
		17,544.66
Total		$302,780.82

Owing to the fact that less than a year has elapsed since the improved system of collection and disposal was placed in operation, the operating costs have not yet been made known.

During 1908 and 1909, with the old system, the total costs of collection and disposal by burial were, respectively, $36,000 and $40,706. The unit costs on the basis of these figures were as follows:

	Cost per Capita	Cost per Cu. Yd.	Cost per Ton.
1908	$0.212	$1.587	$2.667
1909	0.231	1.469	2.467

DEAD ANIMALS.

The removal of carcasses of large animals has always been privately attended to without municipal supervision. The private companies have given efficient service in the removal of large animals inasmuch as this class of waste has a value which can be realized by proper treatment. One company is at present engaged in the rendering business several miles southeast of the city and receives almost all of the animals collected in the city.

Recently the city has provided equipment for the collection of dead animals and carries on the work to a limited extent. The carcasses are hauled directly to the municipal reduction plant and are handled with the garbage.

The removal of small animals, living and dead, is cared for by the garbage department. A dog collector is employed to gather living animals which are kept for a week or more at a pond near the garbage loading station. They are then killed and delivered with the garbage to the reduction works. The carcasses of the smaller animals are removed by garbage collectors. As an indication of the extent of this work, there were disposed of during 1910 by the garbage department, 4503 dogs, 1310 cats, and 1582 miscellaneous small animals.

No accurate records have been kept giving the number or cost of collection of large animals.

ASHES AND RUBBISH.

The collection and disposal of this class of city waste has for many years been carried on by private collectors. The city has provided for and is now equipping a department for the removal and disposal of ashes and rubbish, and this work will be carried on under the supervision of the garbage department. The existing methods of private collection and disposal have been carried on without organization or municipal control. The material is collected at infrequent and irregular intervals from the households throughout the city and disposed of by dumping upon low land at convenient points. The result of this promiscuous dumping has caused unsightliness in many portions of the city. There are, however, several large dumping grounds located upon private property, the owners of which have permitted dumping in order that otherwise undesirable property may be improved. The dumps have been neglected or poorly managed, are often permitted to burn, and are generally objectionable to the vicinity in which they are located.

STREET CLEANING.

The failure on the part of the city authorities to maintain reports and records of the street cleaning department in the past renders it impossible to give an account of past experience in this work. The street cleaning department has been municipally operated for a number of years but until recently its equipment has been insufficient for the needs of the city. The department is at present undergoing improvements and extensions and is rapidly becoming well organized and efficient.

The street cleaning department is a subdepartment of the department of public service and is directly under the supervision of a street cleaning superintendent appointed by the mayor. The superintendent employs a clerk, foreman, and laborers necessary for the work. It has

recently become the custom at Columbus to man the entire department with negroes and all of the employees in this service including the superintendent are of that race.

The work of street cleaning is extended to practically all of the paved streets of the city. The central and main residential sections, however, receive frequent attention, while the less important streets of the city are frequently neglected, being cleaned as rarely as once a year. The equipment of the department consists of 8 flushing machines, 17 sprinkling wagons, 9 machine sweepers, 35 white wing outfits, 23 dump wagons, and other miscellaneous supplies. The department owns no horses, excepting one provided for the superintendent, and all teams are hired by the day with a driver.

Methods of Street Cleaning. During 1910, the first year for which records are available, the principal methods of cleaning were machine sweeping and hand cleaning. Approximately equal areas were cleaned by these methods. Flushing was also used to some extent and in the central portion of the city was the principal method employed. In table No. 61. are shown the relative areas cleaned by the different methods during 1910, and the quantities of material removed.

TABLE NO. 61.

AREAS CLEANED BY VARIOUS METHODS OF STREET CLEANING.

Method.	Areas Great Squares.	Percentage.	Cubc Yards Dirt Removed.	Cubic Yards per Great Square.
Machine Cleaning	88,516	46.4	35,668	.43
Hand Cleaning	84,024	44.1	14,088	.17
Flushing	18,221	9.5	9,357*	.51
Total	190,761	100.0	59,113	.31

* Including catch basin cleanings.

In cleaning by means of flushing machines, it is the practice at Columbus to operate the machines independently. This method is not the usual custom where flushing is extensively used and may account for the somewhat higher cost of the work at Columbus. By this method it is necessary for the flusher to return over the same area a second time in order that the dirt be flushed to the gutters. The material collecting in the gutters is swept in piles and removed within twenty-four hours after flushing. The cleaning of catch basins within the area covered by the flushers is attended to by the street cleaning department and must

be frequently done to prevent stoppages. The flushing leaves the surface of the street almost perfectly cleaned and creates no nuisance from dust.

In machine sweeping one or more machines are used. These follow closely a sprinkling cart by the use of which an attempt is made to reduce the dust. This result is rarely accomplished and the operation of the machine sweeper is quite frequently attended by the creation of clouds of dust which settle upon walks and lawns nearby. The material swept to the gutter is gathered into piles by laborers supplied with brooms and shovels, and placed into a dump cart which follows.

Hand or white wing cleaning is confined chiefly to the central portion of the city and to asphalt paved streets in the main residential portions. Each laborer employed in this work is equipped with a small cart and a number of cans, a broom, shovel and scraper. He is assigned to a certain area which must be covered each day. The cleanings are gathered daily from the cans by dump wagons. In connection with the hand cleaning in the down town portions, rubbish boxes are provided at street intersections, and these tend to reduce the littering of the streets.

All street cleanings are hauled to dumps located in various parts of the city. The department expends but a small amount for dump maintenance, and as the majority of the dumping grounds are privately owned, the city gives little attention to their proper care. The result of the disposal of street cleanings in this manner does not create a nuisance, although it produces unsightliness at the dump.

During the winter months and following excessive snowfall, the department is entirely devoted to snow removal in the down town portions. During this time of course no street cleaning is done. In January and February, 1910, heavy snows occurred, and the department without additional equipment removed 41,000 cubic yards of the material. A short haul was in all cases possible as the material was dumped into the main intercepting sewer, the course of which is within 500 feet of the business portion of the city.

Cost Data. The original cost of the equipment of the street cleaning department is not known. A recent inventory taken in 1910 indicates the present value of the equipment to be $12,170. This does not include land or buildings owned by the department.

In table No. 62 are given the total and unit costs for the maintenance of the street cleaning department for 1907, 1908, 1909 and 1910, and in table No. 63 are given the costs for 1910 of the various methods used. It will be noted that there has been a gradual increase in the amount of money expended for street cleaning during the years for which the figures are given.

TABLE NO. 62.

COST OF STREET CLEANING.

1907-1910.

Year.	Total Cost.	Cost per Capita.	Cost per Great Square.	Cost per Cu. Yd Dirt Removed.
1907	$78,289	$0.478	.....	.....
1908	90,190	.530	.....	.....
1909	96,285	.547	.....	.....
1910	101,148	.561	$0.530	$1.71

TABLE NO. 63

COST OF VARIOUS METHODS OF STREET CLEANING.

1910.

Method.	Cost.*	Average Cost per Great Square.
Machine cleaning	$37,759	$0.426
Hand cleaning	38,169	.391
Flushing	16,781	.92
Sprinkling	8,439	.....
Total	$101,148	.....

* Total cost including overhead expense.

NIGHT SOIL.

The city has never undertaken the work of removing night soil, although the work which is privately done has been carried on under municipal regulation. In the past a number of licensed vault cleaners have been engaged in the work and have disposed of the material by burial either upon the garbage farm or at other suitable points outside the municipality. There is at present only one company performing this work and it operates under an exclusive license. The municipal regulations provide that the work be done between the hours of 10 P. M. and 6 A. M., and that the waste material be removed in watertight wagons.

In 1910 the city erected a night soil dumping station on the same property with the garbage loading station, and since that time all of the material is disposed of by this means. The night soil is screened and flushed into the main intercepting sewer, through which it passes to the sewage purification works.

DAYTON.

Dayton is located in the southwestern portion of the state on the Little Miami River at the point of confluence of that stream with the Mad and Stillwater rivers. The area included within the corporation limits is about 15 square miles. The population, according to the 1910 census, is 116,577. In the accompanying table it will be seen that the growth of the city since 1880 has been very flourishing.

Year.	*Population.*	*Percentage. Increase.*
1880	38,678	26.9
1890	61,220	58.3
1900	85,333	39.4
1910	116,577	36.7

The topography within the city and in the surrounding country is generally quite level. There are sections, however, where the topography is rolling, but no portion of the city is the haul of collection wagons made difficult.

Dayton has in recent years become an important manufacturing center and contains a number of large industries, the most important of which are cash register works and car shops.

The city is well supplied with municipal improvements, having a satisfactory public water supply derived from driven wells; an adequate sewer system constructed on the separate plan; paved streets; and well organized departments for the collection of city wastes and street cleaning. The general appearance of the city is very favorable and, it should be stated, the city authorities are greatly assisted in maintaining cleanliness by an unusually well developed city pride.

The departments for the collection and disposal of city wastes and street cleanings are placed under the general direction of the public service department. In immediate supervision of the work there is a superintendent of street cleaning, who has direct charge of garbage collection, rubbish and ashes collection and street cleaning. The disposal of garbage collected by the city is carried on by a private company, the Dayton Reduction Company, which operates under a contract with the municipality. Other wastes are disposed of by the city.

GARBAGE.

Previous to 1897 the collection and disposal of garbage were carried on by licensed scavengers and there was but little organization in the work. The material was dumped on land or into the Miami River and objectionable conditions prevailed. In 1897 the city inaugurated municipal collection and constructed a crematory of the Dixon type for the

disposal of the garbage. The crematory was destroyed by fire in 1899, and thereafter until 1905, the garbage was disposed of by dumping, as was the custom previous to the building of the crematory. In 1905 a private company, the Dayton Reduction Company, was organized to dispose of the garbage collected by the city, and the work has been carried on in this way until the present time.

Present Methods.

The garbage collection is carried on by a branch of the street cleaning department, which is a sub-department of the public service. The street cleaning superintendent is in general charge of the work, the details of which are attended to by assistants and inspectors. The drivers and laborers are all employed by the superintendent and are retained without respect to political affiliations.

Garbage collections are made in all portions of the city and during all seasons of the year. It is the attempt to make weekly collections in all of the residential districts, but the outlying districts usually receive less frequent service. This is especially true when the weather conditions are bad or when the collection work is very heavy.

The hotels, restaurants and large apartment houses in the central portion of the city are served daily. The reduction company insists that the city deliver to it all of the garbage, but objects to handling market and commission house wastes. Although there has been some controversy, the city has generally agreed to the company's demands and has delivered practically all garbage from residences, hotels and restaurants, but has not delivered a large quantity of market and commission house wastes.

There are in all nine collection districts, having areas of from one-third to one and one-half square miles, each of which is served by one collection wagon. The average length of haul of the collection wagons from their districts to the loading station is 1.5 miles. The maximum haul is 3 miles, while the minimum is about 0.75 mile. In order to cover the assigned territory, it is necessary for the collection wagon to make at times as many as four trips a day, and this is possible without overwork, due to the short haul.

Equipment for Collection. The equipment of the collection department consists of twelve collection wagons; a loading station; and four cars for transportation of the material to the reduction plant. The department owns no horses, but hires all teams with drivers. The drivers care for the collection wagons, keeping them in private barns, and stables.

The collection wagons are of a special type, consisting of a heavy running gear, upon which is placed a removable steel tank body in which the garbage is collected. There are two sizes of tanks used, the larger

ones for two-horse wagons being 6 feet 6 inches long and 3 feet wide, and 3 feet 6 inches deep, giving them a capacity of 2½ cubic yards. The smaller tanks, designed for one-horse wagons, are 6 feet 6 inches long, 3 feet 4 inches wide, and 3 feet 3 inches deep. Their capacity is 1.8 cubic yards. The large wagon running gears with four tanks cost $360 each, the running gear costing about $140 and the tanks $55 each.

The collection wagons deliver the garbage at a receiving station located in the north-central portion of the city, convenient for shipping. The receiving station is 1.75 miles from the reduction plant. The station consists of a steel and galvanized iron shed and into which a railroad siding extends, its length being sufficient to accommodate two flat cars. The wagons are driven through the shed alongside the cars and the garbage tanks are transferred to the cars by means of a hand-operated crane. One man is in charge of the receiving station and assists in loading the tanks, besides maintaining records of the amount of work done by the collectors.

The cars, of which the city owns four, are flat cars of ordinary construction and are of such size as to accommodate ten tank bodies. Their capacity is, therefore, 25 cubic yards, or 18.5 tons of garbage.

Method of Collection. In order to facilitate collection and assist in the proper removal of the garbage, rules have been passed by the city, providing that proper receptacles covered and water-tight be provided by the householder, and that these be placed within reach of the collector; the rules also provide for the separation of rubbish from the garbage. The enforcement of these regulations has been found to be very difficult and their violation is quite general. An inspection of the greater portion of the residential district of the city revealed the fact that not over 10 per cent. of the households were provided with garbage receptacles of a satisfactory type. It was quite customary to find old tubs, buckets and pans of various kinds used for this purpose. The receptacles were, of course, uncovered. There is also a tendency among the people to include in the garbage dish water and other liquid wastes from the kitchen. The effect of these two practices, namely, the use of uncovered receptacles, and the tendency to include liquid wastes, has a marked effect upon the character of the garbage and increases its moisture content appreciably.

Final Disposal. The plant of the Dayton Reduction Company, where all the garbage is delivered for final disposal, is located just outside the eastern limits of the city a short distance south of the Mad River. The plant is owned by a private company and operates under a contract with the city, by the terms of which it receives all garbage collected within the city delivered at the plant. No bonus is paid by the city or by the company in the transaction.

The general surroundings of the plant at the time of its construction were satisfactory for the location of reduction works. In recent

years a growth in residential extension has taken place in the vicinity of the plant, and there are now a number of houses within a short distance in a southerly direction from the plant.

The reduction works were built in 1905 and consist of two buildings, namely, a main building, which contains the principal reduction machinery; and a drier building which has been recently added. The main building is constructed of steel, concrete and brick, and is fire-proof. It is four stories in height and contains besides the garbage machinery, a power plant and office. The reduction machinery is of the type used in the so-called Edson process of garbage reduction.

The flat cars carrying the wagon bodies filled with garbage are delivered at the plant each evening and are handled on the following morning. An electrically operated crane raises the wagon body from the flat cars to the top floor of the building, where the material is dumped into one of three concrete receiving bins which occupy that floor. Each bin is 12 by 15 feet and about 2½ feet deep. A manhole is provided in the center of each bin through which the garbage is shoveled, the floors being sloped slightly toward the manhole. The garbage is seldom stored in these bins for a greater period than twenty-four hours. The wagon bodies after emptying are washed and steamed by inverting them over a grid of steam and hot water piping. The steaming is continued for a period of about thirty seconds, after which the tank is lowered to the platform. Observation would indicate that the method of cleaning is satisfactory.

From the garbage bins the garbage may be conducted to any of six digesters by means of swivel spouts connected with the manhole openings. The digesters are each 8 feet in height by 5 feet in diameter, and constructed of ⅜-inch steel plates. The capacity of each digester is 4 tons. Each digester is provided with a steam jacket about 4 inches in width, which entirely surrounds the shell of the tank. By means of steam introduced into the jacket the garbage is cooked for a period of about eight hours, a pressure of 60 pounds being maintained within the digester by means of a small air compressor. This pressure is to prevent boiling. In order to avoid corrosion the digesters are lined with cast iron ¾ inches in thickness. After digestion is completed the pressure is released through a 2-inch blow-off pipe, the vapors entering a jet condenser.

From the digesters the garbage is dropped under slight pressure into driers. There are three driers, one being provided for each set of two digesters. The connections from the digesters to the driers are through 14-inch pipes controlled by gate valves. The driers are cylindrical in shape, 8 feet in diameter by 14 feet long, the cylinder being set horizontally. They are steam jacketed with a 3-inch steam space. A shaft carrying fourteen stirring arms extends longitudinally through the drier and during drying this shaft is revolved at a rate of 15 revolutions per minute. Steam is used in the jacket at 60 pounds pressure. During drying the

vapors are drawn off by 8-inch pipes which unite into a 12-inch main extending to the jet condenser before mentioned, located at the top of the building. Here the odors are removed to a large extent, but the exhaust vapors are carried to the boiler fires where they are completely consumed. The process of drying by this means requires fourteen to eighteen hours, after which the material is removed from the drier in an almost completely dry condition.

Recently the practice of completely drying the garbage by this means has been abandoned and only a partial drying of the material now takes place. To complete the drying there have been installed two direct heat driers in an adjoining building. The partially dried material from the steam jacketed driers is carried to the direct heat driers by means of an elevator and chute, the latter discharging into an enclosed storage bin from which it is fed to the driers by hand. The driers are cylindrical in shape, 25 feet in length by 36 inches in diameter, and are constructed of riveted steel plates. The driers are set at an angle slightly inclined from the horizontal and rest on roller bearings on which the shell is revolved. A furnace is located at the charging end of each drier and the hot products of combustion are conducted through the driers. The garbage is turned within the shell by means of six shelves riveted to the shell and extending longitudinally through it. At the discharge end of the driers the dried tankage is taken by a screw conveyor to a bucket elevator, which raises it to the upper portion of the main building where it is stored until subjected to the process of extraction of the grease.

From the storage floor the tankage is conveyed by chutes into percolators, of which there are two. These are steel tanks 6 feet in diameter and 6 feet deep, surrounded by a steel jacket having a 4-inch space. A vertical shaft carries stirring apparatus of six cast steel arms. Naphtha is pumped through the percolator for a period of several hours and by this means practically all of the grease is dissolved and removed from the tankage. After this steam is turned into the percolator at a pressure of 20 pounds and revolving arms operated in order to remove all traces of naptha. The naphtha and vapor are conducted to a condensing apparatus.

The naphtha contained in the grease in solution is pumped into separators, of which there are two. These are double tanks which have the general appearance of an hourglass, except that the upper and lower portions are cylindrical. The upper tank is about 6 feet high by 4 feet in diameter. The lower tank is 7 feet high by 4 feet in diameter. The upper tank is provided with umbrella-shaped and inverted hollow, truncated-cone shaped baffles placed alternately, over which the liquid containing the grease percolates. These baffles are made with steam spaces and the heat thus provided causes the naphtha to vaporize and pass off. The liquid is collected in the lower tank, which is provided with a steam jacket and which causes further vaporization. From the lower tank the

liquid is pumped into the second separator and this operation continues until all of the naphtha has been vaporized. The naphtha fumes are conducted through pipes to a condenser which also receives the fumes from the percolator, and are there liquefied. This condenser is located just outside the building and consists of an open steel tank in which are long coils of pipe, ranging in size from 3 inches near the inlet to 1½ inches near the outlet. The naphtha fumes pass through those pipes and are liquefied by cool water around them. After condensation the naphtha is conducted to a storage tank.

The grease removed from the separators is passed into a treating plant, in the bottom of which is provided a system of piping from which hot air at a temperature of 220 degrees is blown to remove the last traces of naphtha. After this the grease is stored for shipment.

The tankage removed from the percolators after the grease has been extracted is carried by a conveyor to the storage room, where it is screened and stored for shipment. The tailings are pulverized in a jaw crusher and passed through the screen. The tankage is used prinicipally by a nearby fertilizer plant.

The mechanical equipment of the plant consists of four 125 horsepower return tubular boilers, feed water pumps and heater; two condensor water pumps of 1,000,000 and 750,000 gallons capacity, respectively; an air compressor; a vacuum pump; a 250 hosepower Buckeye engine; and a small direct connected generator.

The tankage produced by the reduction process and with the use of direct heat driers is of a dark color and somewhat granular and has a slightly burnt appearance. With the use of steam jacketed driers alone the tankage was brown and more powdery in appearance. The average of analyses of six composite samples collected April, 1909, to June, 1910, is as follows:

Per cent. moisture	20.70
Per cent. ash	15.92
Per cent. combustible matter	63.38
Calorific value (B. T. U.)	5543.
Per cent. ether extract	3.12
Per cent. phosphoric acid (P_2O_5)	1.86
Per cent. nitrogen (Kjeldahl)	2.93
Per cent. potash (K_2O)	0.88

It will be noted that the moisture content is rather high, due to incomplete drying as well as steaming in the percolating process. The grease remaining in the final product (3%) is also somewhat higher than usually obtains with similar reduction processes.

The operation of the plant of the Dayton Reduction Company as whole is somewhat objectionable on account of the production of odor, and it is seriously complained of by nearby residents. It is probable, however, that odors from a fertilizer plant immediately north of the

works are also attributed to the garbage plant. The Edson process keeps the material enclosed from the air until it is dried and this reduces the production of odors. It, moreover, produces no liquid waste, as all liquors are cared for. The condition of the digesters and driers, however, determines largely the production of odors, and as at Dayton they usually leak to some extent, odors are here produced. The use of direct heat driers, moreover, is attended by the production of very foul vapors which are discharged freely into the air.

Quantity of Garbage. In table No. 64 are given records of the quantity of garbage collected monthly during 1908 and 1909. It will be noted that the summer collection is very much higher than at other seasons of the year, and that the minimum occurs during the winter months. A comparison of the records for the two years shows strikingly the improvement which has taken place during that period in the efficiency of the department. The quantity collected in 1909 shows an increase over that collected in 1908 of over 20 per cent.

TABLE NO. 64.

QUANTITIES OF GARBAGE COLLECTED.

	1908				1909			
	Cu. Yds.	Tons.*	Cu. Yds. per Capita.	Pounds per Capita.	Cu. Yds.	Tons.*	Cu. Yds. per Capita.	Pounds per Capita.
January	963	710	.0087	12.8	1,065	790	.0094	13.9
February	989	729	.0094	13.2	1,117	819	.0098	14.4
March	1,030	760	.0091	13.8	1,218	897	.0107	15.8
April	1,033	762	.0091	13.8	1,150	846	.0101	14.9
May	1,104	815	.0100	14.7	1,173	864	.0103	15.2
June	1,283	947	.0116	17.2	1,335	982	.0117	17.3
July	1,325	977	.0120	17.7	1,664	1,227	.0146	21.6
August	1,391	1,026	.0126	18.6	1,750	1,290	.0154	22.7
September	1,350	995	.0122	18.0	1,791	1,325	.0158	23.3
October	1,205	885	.0109	16.1	1,440	1,073	.0127	18.9
November	880	648	.0080	11.7	1,319	972	.0116	17.1
December	926	683	.0084	12.4	1,245	915	.0109	16.1
Total	13,479	9,941	.1220	180.0	16,267	12,000	.1430	211.0

* Tonnage calculated at 1475 pounds per cubic yard.

Character of Garbage. The character of the Dayton garbage has been described in a previous portion of this report and the detailed analyses are presented in an appendix. The garbage is distinguished from that of the other cities of Ohio in its abnormally high moisture

content, which averaged 80.6 per cent. from May, 1909, to June, 1910. This excessive moisture is brought about principally by the use of improper receptacles and the inclusion of liquid wastes by the householders. It has a marked effect upon its appearance and its weight per cubic yard averages 1,475 pounds, an exceedingly high figure for garbage. Its chemical composition is also affected and a general lowering of the various constituents is caused by the excessive moisture.

Cost Data. The original cost of the garbage collection equipment owned by the city was approximately $10,000, and additions have increased this but slightly. The cost of collection is represented by the appropriations made for that purpose ($26,000 per annum during 1907, 1908 and 1909.) These expenditures, however, include minor additions to the equipment of the department. The costs can be given only approximately, as no accurate data is available. Table No. 65 gives the costs for 1907 and 1908.

TABLE NO. 65.

COST OF GARBAGE COLLECTION.

	Total Cost.	Cost per Capita.	Cost per Cu. Yd.	Cost per Ton.
1907	$18,000	.167	.....	.....
1908	21,000	.190	1.56	2.11

The cost of the plant of the Dayton Reduction Company, including additions made to date, is approximately $125,000. The annual maintenance expense, including fixed charges, is approximately $45,000. On this basis the plant is operated without profit to the company.

DEAD ANIMALS.

Dead animals have always been collected privately. Since 1905 the Wuichet Fertilizer Company, an industry affiliated with the Dayton Reduction Company, has removed practically all of the animals from the city. The city authorities have had no trouble arising from neglect on the part of the fertilizer company in prompt removal of dead animals, and complaints have been few. The carcasses of dead animals have a value which may be realized by rendering. This is the process employed by the Wuichet Fertilizer Company, and a valuable animal tankage is produced which is used as a fertilizer base in the preparation of the final product.

The removal of small animals is carried on by the municipal garbage

collection department. A wagon is maintained for this purpose and is in daily attendance to complaints which arise. The animals are shipped with the garbage and handled by the reduction process.

RUBBISH AND ASHES.

The collection and disposal of ashes and rubbish at Dayton has undergone little change since the city took up the work a number of years ago. Previous to the inauguration of city collection the work was improperly cared for by private collectors, and its disposal was unorganized and led to complaints from residents of the vicinity of the dumps.

Present Methods.

The department for the collection of rubbish and ashes is a subdepartment of street cleaning and is correlated to the garbage department, being under the same superintendent. Assistants, foremen and laborers are employed directly by the superintendent, and the maintenance of all equipment and dumps is under his direction. For rubbish and ashes collection the city owns no equipment, hiring all teams and wagons by the day.

Ashes and rubbish are collected from all sections of the city, which is divided into eleven districts, each of which is served by one wagon. The areas of these districts vary from ¼ to 1½ square miles and average 0.8 square mile. The average haul is about 0.66 mile, varying from a maximum of one mile to a minimum of ¼ mile. It is aimed to make weekly collections, but is not usually accomplished, owing to the rather large area per wagon used. Considering the fact that the equipment is not owned by the city and that, therefore, absolute municipal control is impossible, the work carried on by the department is very efficient and satisfactory.

No restriction is placed upon the character of the material which will be collected, excepting that the garbage must be separated. It has been attempted by regulation to provide for the use of proper receptacles, but this has failed as in the case of garbage.

Final Disposal. All ashes and rubbish collected are hauled to dumping grounds conveniently located in various portions of the city. The total number of dumps thus used by the city is sixteen, the largest of which are located upon low land bordering the Miami River. None of the dumps are owned by the city, but privilege is granted by the private owners for the disposal of the material upon the land. The city, however, maintains laborers at the dumps, whose duty it is to attend to the proper placing of the material and the general maintenance of the dumps. The dumping grounds have been located for the purpose of minimizing the length of haul from the various collection districts and the average haul required does not exceed 0.66 mile. The maximum haul for those

sections removed the greatest distance from available dumps is somewhat over one mile. In thus selecting the location of dumping grounds it has not been possible to remove them from built up residential districts and all of the dumps are in close proximity to dwellings. The dumps are in a certain way beneficial to these residential districts, however, as the ultimate result is a recovery of useless land and thereby a creation of available location for dwellings.

Owing to the character of the rubbish and ashes which are collected, the proper maintenance of the dumping grounds presents no special difficulty. The material is quite largely composed of ashes and dirt, which makes an excellent fill. The dumps are moreover, shallow, and this provides the possibility of quickly covering the loose material dumped. In certain sections, however, the dumps have given rise to complaint on the part of nearby residents, owing chiefly to the littering of streets and yards by material scattered by the wind. The odors arising from the dumps are not objectionable, and this is chiefly due to the fact that fires have not been prevalent.

Only a small amount of saleable rubbish is removed from the material brought to the dumps. This is not done by the city, but is permitted to be carried on by persons attempting to earn their livelihood in this manner.

In general it may be said that the disposal of rubbish and ashes by dumping has been satisfactory. By this means the material is conveniently disposed of with a short haul and valuable land created within the city. The greatest objection to the method is the unsightliness caused by dust and refuse scattered by the wind. This could be largely avoided by the exclusion of rubbish from the material dumped.

Quantity of Rubbish and Ashes Collected. In table No. 66 are given records of quantities of material collected monthly during 1909. It will be noted that slight fluctuation occurs during the year and that the winter collections are not higher than for other portions of the year. This is true regardless of the fact that coal is quite generally used as a fuel. The constancy during all seasons of the year would indicate that the equipment of the department is inadequate for sufficiently frequent collections during the seasons of heavy production, and that the department is engaged during the entire year in removing accumulations of weeks or months. The total quantity collected during the year compares favorably with that of Cincinnati, where the production of household ashes is about the same as at Dayton.

TABLE NO. 66.

QUANTITIES OF RUBBISH AND ASHES COLLECTED.

1909.

	Cu. Yds.	Tons.	Cu. Yds. per Capita.	Pounds per Capita.
January	4,077	2,222	.0358	39.1
February	4,140	2,256	.0364	39.8
March	5,082	2,770	.0447	48.7
April	4,808	2,620	.0424	46.2
May	4,539	2,474	.0400	43.6
June	4,444	2,422	.0391	42.6
July	4,822	2,628	.0425	46.3
August	4,762	2,595	.0420	45.8
September	4,622	2,519	.0407	44.4
October	4,800	2,616	.0423	46.2
November	4,604	2,509	.0406	44.3
December	4,714	2,569	.0416	45.4
Total	55,414	30,200	.4881	532.4

NOTE. — Tonnage calculated at 1090. pounds per cubic yard.

Character of Rubbish and Ashes. The results of field and laboratory examinations of rubbish and ashes at Dayton are contained in an appendix to this report, and their character in comparison to that of the material of the other cities of Ohio has been discussed. This waste at Dayton is somewhat different in appearance and composition from that of Cleveland and Cincinnati, the difference being shown principally in the smaller percentage of light rubbish and large percentage of ashes and dirt. This result is due largely to the infrequent collections, which make it necessary for the householder to dispose of a large portion of the combustible rubbish by burning it.

Cost Data. The total annual cost of rubbish and ashes collection is approximately $26,000. This includes hire of wagons, teams, drivers, helpers and caretakers of dumps. On this basis for 1909 the unit costs were $0.23 per capita, $0.47 per cubic yard and $0.80 per ton material collected. These unit costs are lower than obtain in the larger cities, brought about by the short haul, as well as by smaller expenditures to secure frequent collections.

STREET CLEANINGS.

The street cleaning department at Dayton while quite active and efficient, has developed to a very much smaller extent than has been the case in the larger cities of the state. The department is managed by a

superintendent, under the public service department, and during the active seasons of the year about fifty laborers are employed. The work is not carried on at all seasons of the year, being practically suspended during the winter months.

The paved streets of the city, having a total length of about 45 miles, are cleaned by the department, but on all excepting the principal streets the cleaning is somewhat irregular. In the central portion of the city, however, practically continuous cleaning is done, the work being performed by hand labor.

Equipment. The equipment of the department for street cleaning is provided principally for carrying on the machine sweeping methods. Flushing of the principal streets is coming into importance and it is quite likely that the new equipment of the department will be for this purpose. At present the department owns 10 machine sweepers; 2 sprinkling carts; 2 St. Louis flushing machines; 5 dirt wagons; and some 15 outfits for hand cleaning. No horses are owned by the city for this work, all teams being hired with drivers.

The equipment of the department is maintained in wagon sheds and yards owned by the department and located in the central portion of the city. Here also is maintained an office and small repair department.

Methods of Street Cleaning. The principal methods of street cleaning employed at Dayton are hand cleaning and machine sweeping. Practically all of the asphalt-paved streets of the city, of which there are about 43 per cent., are cleaned by hand labor, while streets with other kinds of pavement are generally cleaned by machine sweeping. Flushing is used only in the central business portion of the city.

The hand cleaning method is not, strictly speaking, the white wing method, and usually no receptacles are used in which the material is kept until collected by the wagon. It is the common practice to sweep or scrape the surface by hand, placing the material in heaps in the gutters. It is picked up and removed by the collection wagons daily. The material thus removed is usually quite dry and dusty and the process of loading and dumping it is attended by the creation of a large quantity of dust.

Machine sweeping is carried on in the same manner as is the usual practice. The sweepers are preceded by sprinkling carts and followed by laborers who collect the material into piles in the gutters. This process of cleaning is also attended by the creation of dust.

Flushing, although a method recently adopted, is growing in importance and its use is increasing. At Dayton flushing is used only on smoothly surfaced streets and very satisfactory results are obtained, the streets being rendered almost entirely clean. The operation is not attended by the dust nuisance common to other methods of cleaning.

Final Disposal. The street cleanings removed by the various methods are disposed by hauling them to the most convenient rubbish

dump. Here the material is placed at the surface of the dump, where it serves the purpose of leveling and finishing the top. The disposal of the street cleanings in this way is objectionable when the material is dry and dusty, as a nuisance is caused at the time of dumping or after the material has been dumped and leveled.

Cost Data. Accurate cost data for street cleaning are not available, as the funds of the street cleaning and rubbish-ashes department are not separated. During 1909 approximately $40,000 was expended for the cleaning of streets. This represents $0.362 per capita, which figure is somewhat smaller than that for other cities of the state.

CANTON.

The city of Canton is located in the east-central portion of Stark County and lies between the east and west branches of Nimishillen Creek, just north of their confluence. The area included within the corporation limits is 5,964 acres or 9.32 square miles. The surrounding country is mildly hilly, but the area included in the most thickly built up portion of the city is rather flat.

The population of the city, according to the 1910 Federal census report, is 50,217. The growth in population since 1880 has been very great, as shown in the following table:

Year.	*Population*	*Percentage Increase.*
1880	12,258	41.5
1890	26,189	113.6
1900	30,667	17.1
1910	50,217	63.7

Canton is primarily a manufacturing city and contains a great variety of industries. In municipal improvements the city is provided with a public water supply of good quality derived from drilled wells; a separate system of sewers; and about 25 miles of paved streets.

The general sanitation of the city is given attention by the local board of health, and cleanly conditions are maintained generally in almost all portions of the city.

The wastes of the city, garbage, rubbish, ashes, night soil and manure are all removed privately. The city has provided a crematory for the disposal of garbage, but all other wastes are privately disposed of. A municipal department cares for the cleaning of the streets.

GARBAGE.

No accurate information regarding the garbage situation previous to 1903 is available. It is, however, known that before this time the collection of garbage and other wastes was given but little attention and was not regulated in any manner by the city. This work was performed by private scavengers and the garbage carried to farms outside the city, where it was either dumped on the surface of the ground or fed to swine. Needless to say this early system of collection was unsatisfactory and with the growth of the city improvements became necessary.

During the years 1902-1903 the city constructed an incinerating furnace for the disposal of garbage and dead animals from the city. The improvement was completed in April, 1903. At this time the garbage collectors were licensed and an ordinance provided that all garbage be delivered at the incinerating furnace. The improvement of 1903

indirectly affected the conditions of the collection of garbage, inasmuch as the length of haul was somewhat reduced, permitting greater frequency of collection and a more complete covering of the city. The collection of garbage by a number of licensed collectors, however, became unsatisfactory and inadequate for the needs of the city, and it became necessary to reorganize the system of collection and place it upon a better basis and under municipal control. This system of collection remained in use, however, until August 1, 1910.

In April, 1910, an ordinance providing for the awarding of a contract to a company to engage in the collection of garbage and dead animals was passed. According to the terms of this ordinance bids were received and the contract was awarded to a company known as The Canton Garbage Company, the lowest bidder. This company began to operate under its contract August 1, 1910. By virtue of its contract with the city, The Canton Garbage Company cares for the collection of all garbage and dead animals within the city. In the principal residential portions collection is made once each week, while in the outlying districts collections are less frequent. In the central business portion of the city daily collections are made. A charge to the householder of 7 cents per can is made for its removal.

The equipment owned by The Canton Garbage Company consists of five wagons, ten horses, and several thousand cans. The wagons, which are rather lightly constructed, are built with two floors or platforms, each of which is of such a size as to accommodate thirty 10-gallon cans. The total capacity of each wagon is, therefore, 60 cans or 3 cubic yards. Each wagon is drawn by two horses and the collectors are distributed two to the wagon.

All cans are owned by the company and supplied to the householders as receptacles for the garbage. In collecting the garbage the can containing the refuse is placed upon the wagon and an empty one left in its stead. The contract with the city prohibits the opening of cans containing garbage, except at the incinerating plant, and also provides that after the cans have been emptied at the plant they shall be thoroughly cleaned and disinfected before again being placed in use. The equipment for this purpose is very crude and inefficient, consisting simply of a small boiler for furnishing steam and a platform on which the cans are washed.

The present method of collection appears to be very satisfactory and is a decided improvement over the old unorganized system. The total amount of garbage collected shows a material increase, which indicates more complete and efficient collection. Another important improvement brought about is the absence of objection arising from the appearance and odors of the collecting wagons. In the new system the garbage is kept at all times enclosed from the air and hidden from view.

Method of Disposal.

All garbage collected within the city is disposed of by incineration at a municipally owned and operated plant.

Description of Plant. The crematory is located directly south of the city at a distance of two miles from the central portion, 3/4 of a mile from the built up portion, and 1/4 mile from the southern corporation limits. The land upon which the crematory is located and which is owned by the city, has an area of 9-1/2 acres, and lies between the extension of South Market Street and Nimishillen Creek. It is jointly occupied by the sewage purification works and the garbage crematory. The surrounding country is but sparsely settled and only a few houses are within a radius of 1000 feet.

The crematory is housed by a substantially built brick structure. The building has two stories, the lower one of which is occupied by the furnace proper, and the upper story of which is the charging floor. The building is 23 feet wide by 60 feet in length. A roadway leads from South Market Street to the upper story, where the wagons are emptied.

The destructor is of the Dixon type, built by the Dixon Engineering and Construction Company, of Toledo. The furnace consists of an arched steel shell lined with fire brick, has a total length of 60 feet, and is divided into two cells, each 26-1/2 feet in length, between which a combustion chamber or so-called consuming furnace is located. Each cell is divided into two portions, namely, a furnace for the combustion of auxiliary fuel, and a chamber for the destruction of garbage and refuse. The fuel furnace, which is located at the end of the cell farthest removed from the stack flue, consists of two fire boxes, one about 1 foot 8 inches, and the other about 5 feet 4 inches above the bottom of the furnace. These fire boxes are each 3 feet 8 inches by 5 feet, and have grate areas of 18.3 square feet each. The chamber for the destruction of garbage and refuse extends from the fuel furnace to the stench consuming furnace, which separates the two cells. This chamber is 21 feet in length, 6 feet in width and 9 feet in height from the floor to the top of of the arch of the furnace. The garbage is introduced through three circular holes placed in the top of each cell.

Two of these holes are 30 inches in diameter, while one has a diameter of 36 inches, designed for the introduction of large animals, etc., into the furnace. Arched fire clay bars are placed within the garbage cell at a height of about 4 feet above the floor. The garbage introduced into the chamber rests upon these grate bars and is consumed by flames from the auxiliary fuel furnace which pass both above and below the garbage on their way to the stack. Between the clay grate bars are openings of 5 inches, which permit a considerable part of the garbage to fall through to the floor of the furnace, where it is subsequently consumed. To provide means for stoking and the removal of

ash, doors are located along the front of the furnace in lines just above the clay grate bars and just above the floor.

At the end of each cell farthest removed from the auxiliary fuel furnace and opening leads into the stench consuming furnace, where hot fires may be maintained to completely consume the gases should incomplete combustion have taken place in the furnace proper. The openings are provided with dampers, by which the force of the draft may be regulated. From the stench consuming furnace the gas is passed through a breeching 36 inches in diameter which leads to a stack having internal dimensions of 3 feet by 3 feet, and a height of 83 feet.

Method of Operation. Immediately upon the arrival of the wagons at the furnace the garbage is dumped from the cans directly into the garbage cell. This operation requires a period of about 20 minutes for each wagon, during which time the charging hole must be left open and consequently a large loss of heat takes place. No facilities for the storage of garbage are provided for.

The hours of operation at the plant are from 6:30 a. m. to 5:30 p. m. during six days of each week. The fires are banked each night, and of course the furnace cools to a large extent before firing is resumed on the following morning. One of the cells is operated in this fashion, receiving all the garbage for a period of one week, at the end of which time it is thoroughly cleaned of the residual ashes and allowed to remain idle during the following week while the other cell is in operation. This gives opportunity for repairs which may be required.

With this method of operation it is necessary to start the firing with a cold furnace on but one day each week, although the temperature of the furnace is at a low point when the fires are started each morning. It is the customary practice to partially fill the garbage cell before starting the fires in the auxiliary fuel furnace. Needless to say this results in the creation of objectionable odors for a number of hours until high temperatures are attained in the garbage cell.

While the furnace is in operation, especially at the beginning of the firing when the temperatures are low, the odors in the vicinity of the plant are noticeable. The degree to which these odors are objectionable is also dependent upon atmospheric conditions. The city authorities state that no serious complaints have been made against odors arising from the plant, but this is probably due to the fact that the location of the plant is well removed from dwellings and does not indicate the absence of odors.

The ash produced in the furnace by the combustion of the garbage is usually of a dark gray color and appears to be incompletely burned. The presence of small pieces of unburned garbage throughout the ash also indicates the incompleteness of combustion. The production of this incompletely burned ash is largely dependent upon the work of the operator and is not an inherent fault of the furnace. The ash is disposed of

by dumping upon low ground near the plant. No distinct odor arises from the ash excepting immediately after its removal from the furnace, when portions of the unburned material are still in the process of burning.

Data on the operation of the plant are contained in the results of furnace tests, which are presented in an appendix to this report.

Character and Quantity of Refuse Disposed of. In general the refuse received at the plant may be described as kitchen garbage. Very small amounts of rubbish are received, but almost daily one or two loads of commission house wastes are delivered at the plant. Occasionally dead animals are burned, but this is not frequent

The garbage of Canton as delivered at the plant has been observed on two occasions, namely, in July 1909, and in February 1910. At the time of both of these observations the old system of collection by licensed collectors was in practice, and undoubtedly had some effect on the appearance of the garbage. The appearance of the summer garbage as observed in July 1909, may be described as rather wet vegetable wastes, containing considerable rubbish and consisting largely of fresh green vegetable wastes and melon rinds. The appearance of the winter garbage may be described as being rather wet, containing a medium quantity of rubbish and consisting largely of vegetable and fruit peelings. In general, it may be stated that the Canton garbage appears to be somewhat wetter than the average for other Ohio cities, and to contain a somewhat larger percentage of rubbish.

Previous to March 1910, no records were kept at the plant of the quantity of garbage treated, and only figures representing a rough approximation can be given. Since March 1910, accurate records have been kept and based upon these reports it appears that during the year 1910 an average of about 8 cubic yards of garbage were consumed each working day during the year. During the winter season, from November to April, the quantity varied from 5 to 8 cubic yards per day, while the summer season, from May to October, 10 to 15 cubic yards of garbage were burned daily. Under the new system of collection the indications are that the quantity of garbage treated will increase and that an average of 15 cubic yards will be received during the winter months and 20 to 25 cubic yards during the summer months. No record of the coal consumption required for burning the garbage has been kept.

In table No. 67 is a record of the quantity of garbage received from March to December, 1910.

TABLE NO. 67.

QUANTITY OF GARBAGE COLLECTED.

1910	Garbage.				Miscellaneous Refuse.
	Cu. Yds.	Tons.	Cu. Yds. per Capita.	Pounds per Capita.	Number of Loads.
March	183	110	.0036	4.3	51
April	221	133	.0044	5.3	61
May	256	157	.0051	6.1	58
June	339	203	.0067	8.0	82
July	337	202	.0067	8.0	102
August	575	345	.0114	13.7	94
September	739	443	.0147	17.6	75
October	681	409	.0135	16.2	71
November	605	363	.0120	14.4	52
December	485	91	.0097	11.7	45
Average	442	265	.0088	10.6	69

It will be noted in the above table that beginning with August, the quantity of garbage collected was very much in excess of that collected during the preceding months. This is probably accounted for by the introduction of the new and more efficient system of collection.

Cost Data.

The original cost of the incinerating plant was $20,277.90. All additional costs since the first installation have been charged to operation and maintenance, and the cost to date, which represents an amount in excess of the original cost, cannot be accurately given. The cost of repairs on the plant have been due almost entirely to the necessity of replacing the fire clay garbage grates and repairing of the fire brick lining of the furnace. No extensive repairs have ever been found necessary, but the repair of the garbage grates necessitates a constant expenditure for the upkeep of the plant. Tables Nos. 68 and 69 give the cost of maintenance and operation, and the unit cost of same, compiled from figures furnished by the department of public service.

TABLE NO. 68.

COST OF MAINTENANCE AND OPERATION.

Year.	Salaries.	Coal.	Repairs.	Incidentals.	Total.
1903	$414.00	$342.35	$279.35	$85.98	$1,121.68
1904	690.00	682.63	47.24	76.95	1,496.82
1905	532.50	521.53	12.50	90.13	1,156.66
1906	577.50	573.06	144.54	213.29	1,508.39
1907	657.25	707.80	2,166.10	140.28	3,671.43
1908	600.00	1,075.48	647.90	28.26	2,351.64
1909	730.00	982.58	244.30	42.46	1,999.34

TABLE NO. 69.

UNIT COSTS OF MAINTENANCE AND OPERATION.

	Total Cost per Capita.	Total Cost per Ton (approx.)	Fuel Cost per Ton (approx.)	Estimated No. Tons Garbage Consumed During Year.
1903	$0.031	$2.20	$0.67	510
1904	0.089	2.50	1.13	600
1905	0.029	1.68	.77	684
1906	0.036	1.97	.75	748
1907	0.083	4.30	.83	852
1908	0.051	2.50	1.15	936
1909	0.042	1.78	.97	1,020

NOTE: — Average weight 1200 lbs. per cubic yard.

RUBBISH AND ASHES.

Household rubbish, ashes, etc., are collected and removed by miscellaneous scavengers. The removal of this class of refuse is performed in an unorganized and haphazard way and receives no attention from the city departments. All refuse is disposed of by dumping and none is delivered at the garbage incinerating plant.

Very irregular schedules of collection are maintained and the city is imperfectly covered by the wagon routes Several of the dumps visited presented a very disorderly appearance and indicate that extreme lack of care is exercised in properly dumping the material. The city, it may be noted, maintains no caretakers for the care of dumps.

STREET CLEANING.

Canton maintains a well equipped and very efficient street cleaning department. Its development is of a high order for a city of 50,000 population, and its work adds much to the favorable appearance of the city.

Previous to 1880 the city maintained no department for the care of its streets. In 1880, the first paved street in the city was constructed and this marked the first movement in the establishment of a street cleaning department. No efficient organization was made, however, prior to 1886. In this year the organization was greatly improved and more efficient work accomplished. Throughout this early history of the street cleaning department the city did not own any equipment for the purpose. All teams used for removal of street cleanings were hired by the day and various other street work, such as grading, etc., was performed by contract.

The city did not undertake an efficient organization of a street cleaning department until 1906, during which year extensive improvements were made. These improvements included the purchase of a property for the location of stables and wagon yard, the purchase of teams and wagons, and various other minor equipment.

Present Methods of Street Cleaning. The street cleaning department, a branch of the public service department, is under the direct supervision of a street superintendent. One clerk is employed, but no foremen or inspectors are used. During the summer season, when the department is most actively engaged, 40 to 45 laborers and teamsters are employed in the department. These employees are hired directly by the superintendent, no consideration being given to political tendencies.

The street cleaning department is apparently well organized and disciplined and its superintendent appears to give his closest attention to the work. The work of the department is somewhat interfered with owing to lack of sufficient funds to carry out the work as completely as desirable. The duties of the department include the grading of streets, repair of pavements, etc., besides the actual street cleaning.

The total length of paved streets, which also represents the length of streets cleaned, is 27 to 30 miles. All pavements are constructed of vitrified brick. Within the city there are also 125 miles of unpaved streets, which are given some attention by the street department. Those streets, however, are cleaned very irregularly.

The equipment of the street department includes 14 horses; 3 street flushers of the Cleveland type; 7 dirt wagons; 2 sanitary carts for cleaning catch basins; and various other minor equipment.

The principal methods of street cleaning employed are flushing and hand cleaning. Machine sweeping is not used, having been entirely sup-

planted by the more modern and sanitary methods. During the greater portion of the year the principal paved streets of the city are flushed weekly, while in the main portion the streets are hand broomed daily.

During the winter months the street cleaning department is practically at a standstill. No attempt at snow removal is made. A snow plow, however, is operated by the department for the cleaning of the sidewalks.

The street cleanings are disposed of on dumps located within the city in the valleys of the east and west branches of Nimishillen Creek. During certain portions of the year, especially in the spring, the cleanings are used by citizens on gardens and lawns as fertilizer.

No recent appraisement of the property owned by the street department has been made. It is thought, however, that the fixed plant, including the stables, etc., are valued at about $6,000, while the moveable plant, including the horses, flushers, wagons and minor equipment are valued at about $7,000. The operation costs are controlled by the amount of the appropriations and have never exceeded $12,000. This appropriation is inadequate for the requirements of the department and does not permit of as extensive work as is desirable.

CATCH BASIN CLEANING.

Until the improvements were made in 1906, catch basin cleaning was not an important work of the street cleaning department. With the use of flushing machines, however, the necessity of regular cleaning of catch basins became evident, and it was therefore necessary to equip the department for this purpose. The activity of the department in this work is regulated by the operation of the flushing machines and during the winter months catch basin cleaning requires little or no attention.

The equipment of the department for this purpose consists of two so-called sanitary carts for the removal of the cleanings. These carts are constructed of riveted sheet steel plates and have a semi-cylindrical section; their capacity is about one yard each.

In cleaning catch basins two carts, one driver and two laborers are required, the driver being engaged continuously in removing and emptying the carts. The waste material is disposed of by dumping in the same manner as street cleanings.

No data giving the quantity of material removed, number of each basins cleaned or costs are available.

MANSFIELD.

The city of Mansfield is located in the central portion of Richland County at the headwaters of Rocky Fork, a branch of the Mohican River. The area of the corporation is about five square miles, and its population according to the 1910 Federal census is 20,678. The city is at present undergoing a rather slow growth as is shown by a study of the following table, which gives the census reports for all available years:

Year.	*Population.*	*Percentage. Increase.*
1850	3,553	....
1860	4,581	29.0
1870	8,029	75.3
1880	9,589	19.4
1890	13,473	40.5
1900	17,640	30.9
1910	20,768	12.1

Mansfield is a thriving manufacturing center, its industries being largely devoted to iron and steel manufacturing. The city is provided with a number of municipal improvements, including a public water supply, installed in 1870; sewerage and a sewage purification plant built in 1902; and a municipal garbage crematory, which is operated in conjunction with the sewage pumping station.

GARBAGE.

Previous to 1901, the collection of garbage, as well as of other wastes, received very little attention from the city authorities. In 1901, at the time of the building of the garbage crematory, an attempt was made to institute an improved system of collection, and a contract was entered into between the city and a private collection company for gathering of garbage. By the terms of this contract the householder was put to no expense, all of which was borne by the municipality. The waste was disposed of largely by feeding to hogs and but a small quantity was delivered to the crematory. After this system of collection had been used for several years it became unsatisfactory to the needs of the city, owing largely to negligence on the part of the collecting company, but no improvement was made until 1908. In this year a company was organized under the name of the Sanitary Garbage Company. and under a bond of $3000 secured a three-year contract from the city for the collection of garbage. This company began to operate under its contract on June 1, 1908. Weekly collections are made in the residential portion of the city and the householder pays for the removal of garbage at the rate of 10 cents per can.

The equipment of the company consists of two wagons, four horses and about 2000 cans. The wagons are rather lightly constructed, built with two floors or platforms, each of which is of such size as to accommodate 30 cans. The total capacity of each is therefore three cubic yards. All cans are owned by the company and supplied to the householders as receptacles for the garbage. In removing the waste the full can is placed upon the wagon and a clean, disinfected one left in its stead. All garbage collected by the Sanitary Garbage Company is delivered to the garbage crematory. After emptying, the cans are washed and disinfected before being again placed in use.

The present collection system, while it cannot be considered to offer a permanent solution of the problem of garbage removal, at present appears to be very satisfactory for the requirements of the city. The wagons present a cleanly appearance and the cans being closed tightly, small objection is caused from odors. The company does not cover the city completely and those districts which are not served by the so-called can system must depend upon independent scavengers for the removal of garbage. A few of these scavengers still continue in business and deliver the material to the crematory.

Method of Disposal.

Description of Plant. The garbage crematory at Mansfield is located east of the city about 500 feet outside the corporation line. The land upon which the crematory is located is owned by the city and has an area of 16 acres. It lies between the Pennsylvania Railroad and the Rocky Fork of the Mohican River south of the Wooster Road, and is jointly occupied by the sewage purification works and pumping station and the garbage crematory. The surrounding country is but sparsely built up within a radius of 1/4 of a mile. The edge of the thickly built up portion of the city lies about 1/2 mile to the westward, and there is a small suburban settlement at about the same distance east of the crematory.

The garbage crematory and sewage pumping station are housed in a neat appearing brick building. That portion occupied by the sewage pumps is 28 by 38 feet in plan, and the main portion of the building which houses the boilers and the garbage crematory is 33 by 48 feet in plan. This portion of the building has an upper story which is used as the charging floor of the crematory, and which is reached by means of an inclined roadway. A coal bin for the storage of fuel is also provided, into which the cars may be dumped directly from the track.

The destructor is of the old Dixon type, built by the Dixon Garbage Crematory Company (now the Dixon Engineering and Construction Company) of Toledo. Its nominal capacity is 15 tons per 24 hours. The furnace is constructed with an arched steel shell lined with fire

brick, and has outside dimensions of 21 feet in length, 7-1/2 feet in width, and 10 feet in height. The furnace consists of a single cell which is made up of three parts, namely, a furnace for the combustion of auxiliary fuel; a chamber for the destruction of garbage and refuse; and a so-called stench consuming furnace. The fuel furnace is located at one end of the cell; the stench consuming furnace at the opposite end; and the space between is occupied by the garbage chamber. According to the design of the furnace, the fuel furnace was to have consisted of two fire boxes, one placed above the other in such a way that the gases from one would pass above, and from the other below the garbage to be burned. Modifications in the design, however, provided for the use of the lower fire box only. In the original design the gases from the fuel fires were to have been conducted through the garbage combustion chamber and the stench consuming furnace, passing directly to the stack flue to be placed at this end of the furnace. The construction of the furnace as built, however, provides for a reversal of the draft within the garbage cell. The gases from the lower fuel fire pass along the lower portion of the furnace to the opposite end and rising return along the upper portion through the upper fire box to the stack flue, which leaves the furnace at this point. Before reaching the flue the gases pass through a checkerwork of firebrick, which serves to effect a more thorough mixing and better combustion of the gases. No damper for the control of the draft is provided.

The chamber for the destruction of garbage and refuse has internal dimensions of 12.5 feet in length, 6 feet in width, and 9 feet in height, from the floor to the crown of the furnace. Two rectangular openings are placed in the top of the cell for the introduction of garbage and refuse. Within the cell arched fire clay grate bars are placed at a height of about 4 feet above the floor. Openings of 5 inches between these grate bars allow a portion of the garbage to fall below, but the greater percentage is retained resting upon the grate bars. To provide means for stoking of the garbage and removal of ash, doors are located along the front of the furnace in rows just above the clay grate bars and just above the floors.

The path of the gases from the auxiliary fuel fire through the garbage cell is controlled by the point of application of the garbage to be burned. It is the custom to keep the garbage grates near the fuel fire well covered with garbage and thus force the gases from the fire to pass to the opposite end of the furnace in order to reach the upper portion and pass into the stack flue. This method of operation has the decided advantage of requiring but a small amount of stoking.

When the furnace was originally built, the products of combustion were conducted into the back-pass of the boilers and used to supply heat for the generation of steam. It was thought by this means that a large amount of the waste heat from the furnace might be utilized.

It was found, however, that the tubes of the boilers became coated with a hard carbonaceous deposit which was very difficult to remove, and accordingly the connection with the back-pass was abandoned. The gases now enter the stack flue leading from the boilers at a point near the base of the stack. The stack which serves to supply a draft for both the furnace and the boilers, is well constructed and has a height of 80 feet and an internal diameter of 5 feet.

Method of Operation. The garbage crematory is operated during the greater portion of each day, but remains idle during the night unless an unusually heavy collection requires night operation. Two men are on duty during the day and one at night to attend to the operation of the sewage pumps, and the garbage crematory may therefore be operated at all times.

The garbage is placed within the cell immediately upon the arrival of the wagon, no facilities for storage being provided. The emptying of one wagon load requires a period of from 20 to 30 minutes, during which time the charging hole of the furnace must be left open. A large loss of heat occurs as a result of this operation In dumping the garbage it is the practice to keep that portion of the grate nearest the fire box well covered to prevent a short circuiting of the gases in their passage through the cell.

The firing of the furnace is carefully attended to and owing to the fact that the boiler firemen also care for the operation of the crematory, proper firing is accomplished. The garbage is burned at a high temperature, maintained betwen 1200 and 1300 degrees nearly all of the time. The introduction of garbage lowers the temperature for a short time, but the heat is quickly regained after the dumping operation is completed. No odors are complained of in the vicinity, and it is reasonable to suppose that no serious odors are created by the operation of the plant.

The ash produced by the burning of the garbage is of a dark gray color, very finely divided, and free from objectionable odor. The ash is removed from the furnace each day and disposed of by dumping on low land near the plant.

Character and Quantity of Refuse Destroyed.

The only class of refuse received at the plant for destruction is kitchen garbage obtained almost entirely from residences. No rubbish, and but few dead animals, are received.

The garbage delivered at the plant has been observed on but one occasion, namely, in November 1909. At that time the garbage was rather wet and dirty, its principal constituents being potato parings and fruit peelings. The garbage is entirely of household origin, none being collected from hotels, restaurants, etc.

Previous to June 1, 1908, when the Sanitary Garbage Company began operations, no records as to the quantities of garbage collected were kept. Since that time records have been maintained by the company, showing in a general way the quantity of waste collected. The records are, however, in rather poor form and it is not thought that they are complete or accurate. From them the following figures were taken to indicate the quantity of garbage removed.

TABLE NO. 70.

SUMMARY OF GARBAGE COLLECTED — 1909.

	Total for Year.	Average per Month.
Cubic yards	1,680	140
Tons*	1,012	84.3
Cubic yards per capita	.082	.0068
Pounds per capita	99	8.3

* Estimated at 1250 pounds per cubic yard.

Cost Data.

The original cost of the garbage crematory was $6,000. This includes the furnace alone, and according to the designing engineer's estimate, the total cost of the plant, including a proportionate cost for the building, flues, stack and other accessories used jointly by the sewage and garbage plants, was $12,000. No changes or additions in the construction of the furnace have been made since its installation. No record of the cost of repairs has been kept, but it may be stated that the repairs have been neither costly nor extensive, and have been confined principally to the replacement of fire clay linings, grates, etc.

The cost of operation and maintenance of the plant is included in the records for the combined sewage and garbage plants, and no attempt is made to keep even approximate figures for the cost of each. It is therefore impossible to give total or unit costs for maintenance and operation.

DEAD ANIMALS.

At Mansfield the removal of the carcasses of dead animals has always been carried on by private enterprise. The greater number of the larger animals are disposed of by rendering, but a few of them are received at the garbage crematory where they are burned with the garbage. The city maintains no equipment for the removal of either the larger or small animals; and the latter are disposed of either by burial

within the city or by removal with the garbage. Although there is no organization in the work of removing dead animals, but little complaint has arisen owing principally to the small number requiring removal.

RUBBISH AND ASHES.

The city has never undertaken the collection and disposal of this class of waste material and the work has always been in the hands of independent scavengers. There is no organization in the work and neither is the city entirely covered by the collection wagons nor are those districts served given efficient attention. The expense of removal being entirely upon the householder tends to prevent complete collection of the waste material.

Rubbish and ashes are disposed of by dumping at points well removed from the built up portions of the city. The dumps, however, receive little attention or supervision and are objectionable in their immediate vicinity.

MARION.

The city of Marion is located in the central portion of the state upon the drainage area of the Scioto River. It covers an area of about seven square miles. The topography of the city and surrounding country is rather flat. The present population according to the 1910 Federal census is 18,232, and by consulting the following table it will be seen that the city has for the past twenty years enjoyed a flourishing growth. Recent census reports are as follows:

Year.	*Population.*	*Percentage. Increase.*
1890	8,327	....
1900	11,862	42.4
1910	18,232	53.7

Marion is growing to be an important manufacturing center and contains a large number of industries, the principal of which are engaged in the manufacture of steam shovels. The city is provided with a number of municipal improvements, including a privately owned water supply; a complete system of sewers; a sewage purification plant; a municipal garbage crematory; and a number of miles of paved streets. The city maintains no department for wastes collection, but there is a fairly well equipped street cleaning department.

GARBAGE.

Previous to 1906, Marion had no efficient system of garbage collection. The collection was made by independent scavengers and, as is the usual result, this system of collection became very unsatisfactory as the city grew. The garbage was disposed of by dumping either upon a 6-acre tract of land east of the corporation limits owned by the city or into an abandoned stone quarry within the city.

In 1904 plans were made for the construction of a garbage crematory to be built in connection with sewage purification works. The improvement was made in 1905 and placed in operation in October of that year. Following the installation of the crematory an improvement in the collection system was brought about by the establishment of a private collecting company. This company has since its formation, operated without a contract or a franchise from the city. The company furnishes a 12-gallon can weekly to each customer and removes the garbage at a cost of 10 cents per can, paid by the householder The system is similar to that in practice at Mansfield, but is not so efficiently managed. The collecting company now attends to the removal of almost all of the garbage produced within the city, but owing to the fact that the cost of removal rests entirely upon the householder, the collection is not complete. A few independent scavengers remove a small portion

of the garbage, but their work is mainly confined to the removal of rubbish.

Method of Disposal.

All garbage collected by the collecting company and independent scavengers is hauled to the municipal crematory and burned at city expense. Offal from slaughter houses, dead animals and, until recently night soil, are also disposed of in this manner, although for these classes of waste the city charges a fee for their disposal.

Description of Plant. The crematory, which is operated jointly with the sewage purification works, is located 3/4 of a mile west of the edge of the built up portion of the city, and about two miles from the business portion. The plant was constructed in 1905, and placed in operation in October of that year. The building housing the plant is immediately north of the sewage purification works, its south wall being built directly over the north wall of the grit chamber. The building is a one-story brick structure with a basement, in which is placed the furnace proper.

The crematory is of the Walker type, patented by Mr. R. S. Walker. The furnace is constructed of common brick lined with fire brick and entirely enclosed in a shell of cast iron plates bolted together. It is 20 by 20 feet in plan, and at the center is a circular brick stack 4 feet in diameter.

The southerly half of the furnace is semi-circular in plan built about the stack at the center, while the northerly half is rectangular. Across the northerly end of the furnace are two fire-boxes and between them a cell designed for the burning of animals and miscellaneous refuse. The annular space between the stack and the outer wall of the furnace in the southerly portion is 5 feet in width. An evaporating floor of cast iron plates is placed in this space, 5 feet 4 inches below the crown of the furnace and 2 feet 6 inches above the bottom. The space above the evaporating floor is used for the drying and burning of garbage, etc., while the space below conducts the gases to the stack, acting as a dust arrester. Every fourth or fifth plate in the evaporating floor was designed to be revolved for the purpose of removing ashes to the space below. This practice has, however, been found impracticable and is not employed. Doors giving access to the spaces above and below the evaporating floor are provided.

Dampers are so arranged that the draft may be conducted in either direction through the cell. The gases pass from the firebox, supplying the heat for combustion over the evaporating floor upon which the material is placed, around the stack, and, reversing their direction, through a damper opening, into the space below the evaporating floor, from which they enter the stack through an opening in its southerly wall. In case it becomes necessary to heat the products of combustion in order to deodorize them before they enter the stack, the second firebox is used.

The furnace is designed for the use of either coal or gas as a fuel. Natural gas, costing 15 cents per 1000 cubic feet, has been used since the installation of the plant and is giving satisfactory results.

Method of Operation. The furnace is operated intermittently, being used each day during the working hours of the plant, from 6:30 a. m. to 5:30 p. m. Night operation is never employed.

The refuse is placed within the cell immediately upon its arrival. The regularity of operation is therefore entirely dependent upon the regularity of arrival of the collection wagons. The furnace is fired with natual gas and therefore constant conditions of firing are attained, independent of the attention given by the operator. The principal labor attending the operation of the plant is the stoking, which must be frequently done in order to accomplish destruction of the material. According to the design of the furnace, the evaporating floor is provided only for the drying of the material, the fire boxes being provided for its ultimate destruction. This method of operation is not followed, however, and both drying and burning take place on the evaporating floor. It is apparent, therefore, that the stoking is an important feature of the operation, and without frequent stoking it is impossible to bring the air necessary for combustion in contact with the material.

The direction of the draft through the furnace is alternated according to the judgment of the operator in order to accomplish destruction of the material on both sides of the cell. The temperatures attained within the cell are not great, and the destruction of the material takes place rather slowly. The slow action of the furnace is also to a large extent accounted for by the class of material burned, which until recently has consisted largely of night soil.

Ashes are removed directly from the evaporating floor almost daily, the frequency of removal depending upon the degree to which the ashes appear to have been consumed. The ash from the garbage is of a dark grayish color and is usually well burned. That from the night soil is a light gray powder, very slightly palpable and without odor. The ashes are disposed of by dumping near the plant and are removed to some extent by nearby farmers for use as fertilizing material.

Character and Quantity of Refuse Destroyed.

The refuse received at the plant is composed of five classes, namely, garbage, mixed garbage and rubbish, night soil, slaughter house offal, and dead animals. No charge is made by the city for the destruction of garbage and rubbish, but the following schedule of fees has been adopted for the destruction of other classes of wastes:

Night soil	25 cents per barrel (50 gals.)
Offal	25 cents per barrel (50 gals.)
Horses and cattle	$2.00 each
Small animals	0.50 each

The garbage is largely of household origin, although a portion is collected from restaurants, hotels, etc. It usually contains only a small amount of rubbish and in general has a rather good appearance. The garbage, mixed garbage and refuse, and slaughter house offal constitute the smaller percentage of the total refuse received, the larger percentage being made up of night soil. The destruction of this class of wastes forms the principal burden which is placed upon the plant.

Previous to the installation of the crematory, no records were kept of the quantity of material collected. Since that time, however, owing principally to the maintenance of a fee system, accurate records have been kept at the plant.

In table No. 71 are given monthly records of the quantities of garbage and night soil received for incineration during 1908, 1909 and 1910. It will be noted that the unit quantities of garbage are very much smaller than those in the larger cities of the state, indicating the incompleteness of removal of the garbage from the city.

TABLE NO. 71.

QUANTITIES OF GARBAGE COLLECTED.

	Garbage.									Night Soil.		
	1908			1909			1910			1908	1909	1910
	Cu. Yds.	Cu. Yds. per Capita.	Lbs. per Capita	Cu. Yds.	Cu. Yds. per Capita.	Lbs. per Capita.	Cu. Yds.	Cu. Yds. per Capita.	Lbs. per Capita.	Cu. Yds.	Cu. Yds.	Cu. Yds.
January ...	56	.0033	4.0	43	.0024	2.9	73	.0040	4.8	2.6	6.6	10.8
February ..	41	.0024	2.9	37	.0021	2.5	44	.0024	2.9	1.1	7.5	10.8
March	50	.0029	3.5	50	.0028	3.4	57	.0031	3.7	13.1	20.4	37.0
April	54	.0032	3.8	51	.0029	3.5	57	.0031	3.7	41.8	30.4	28.0
May	80	.0047	5.6	85	.0048	5.8	47	.0026	3.1	32.2	44.4	29.5
June	88	.0052	6.2	94	.0053	6.4	83	.0046	5.5	45.5	39.4	20.3
July	99	.0058	7.0	120	.0068	8.1	73	.0040	4.8	20.0	28.4	24.2
August	102	.0060	7.2	91	.0052	6.2	71	.0039	4.7	16.7	32.2	9.7
September .	71	.0042	5.0	99	.0054	6.5	58	.0032	3.8	17.5	13.0	none
October ...	61	.0036	4.3	72	.0041	4.9	53	.0029	3.5	2.0	22.5	none
November .	50	.0029	3.5	70	.0040	4.8	47	.0026	3.1	14.2	20.8	none
December ..	49	.0029	3.5	66	.0038	4.6	52	.0029	3.5	11.9	11.2	none
Total	801	.0471	56.5	878	.0496	59.6	715	.0393	47.1	218.6	276.8	170.4
Average ...	67	.0039	4.7	73	.0041	4.9	60	.0033	3.9	18.2	23.1	21.3

In table No. 72 are given summaries of the quantities of various classes of waste materials received during the years from 1906 to 1910.

TABLE NO. 72.

SUMMARY OF QUANTITIES OF VARIOUS WASTES RECEIVED.

	Garbage.			Night Soil.			Dead Animals and Offal.		
	Cu. Yds.	Tons.	Per Cent. of Total.	Cu. Yds.	Tons.	Per Cent. of Total	Tons.	Total Tons.	Per Cent. of Total.
1906	810	486	75.0	115	98	15.0	65	649	10.0
1907	1,040	624	79.5	142	120	15.2	42	786	5.3
1908	801	480	69.0	219	186	26.6	32	698	4.4
1909	878	527	67.0	277	235	30.0	23	785	3.0
1910	715	429	71.4	170*	145	24.0	28	602	4.6

* Eight months.

NOTE: Tonnage estimated as follows:

Garbage	1,200 pounds per cubic yard
Night soil	1,700 pounds per cubic yard
Horses	1,400 pounds each
Cattle	1,200 pounds each
Small animals	50 pounds each

Cost Data.

The original cost of the incinerating plant was $15,000, and this figure represents practically the cost to date. The furnace has been maintained in good repair at small expense, and no changes have been necessary to secure proper operation.

The cost of maintenance and operation with unit costs of the same are presented in the following tables. The figures are compiled from data furnished by the local officials.

TABLE NO. 73.

COST OF OPERATION AND MAINTENANCE.

	Labor.	Fuel.	Repairs and Incidentals.	Total.
1906	$621	$1,178	$410	$2,209
1907	834	875	339	2,048
1908	900	771	640	2,311

TABLE NO. 74.

UNIT COSTS OF OPERATION AND MAINTENANCE.

	Total Cost.	Cost per Capita.	Cost per Ton of Total Refuse.	Fuel Cost per Ton.
1906	$2,209	$0.141	$3.40	$1.81
1907	2,048	0.125	2.61	1.11
1908	2,311	0.137	3.31	1.19

TABLE NO. 75.

NET COSTS OF OPERATION AND MAINTENANCE.

	Total Cost.	Receipts.	Net Cost.	Net Cost per Capita.	Net Cost per Ton.
1906	$2,209	$480	$1,729	$0.110	$2.66
1907	2,048	475	1,573	0.096	2.00
1908	2,311	502	1,809	0.107	2.59

In table No. 73 the total costs itemized under three headings are given, and in table No. 74 these costs are given on the unit basis. It will be noted that the fuel cost which was excessive during 1906 was greatly reduced during the succeeding years. A revenue is derived from burning certain classes of wastes and from the sale of hides removed from dead animals. Deducting these receipts the net costs are presented in table No. 75.

RUBBISH AND ASHES.

The city of Marion has never undertaken the collection of rubbish and ashes, and the performance of this work is incomplete and unorganized.

Independent scavengers attend to the removal of this class of city wastes and dispose of it by dumping at various points at the outskirts of the city. None of the rubbish is delivered at the garbage plant. The dumping grounds are given no attention and their condition is dependent upon the care in dumping exercised by the scavengers.

STREET CLEANING.

The cleaning of streets is accomplished by two methods, namely, by sprinkling and sweeping, and by "white wings," using hand brooms and scrapers.

The city maintains a fairly well equipped department for this purpose and the streets are kept in very good condition. The usual objection due to dust nuisance, however, results from the methods of cleaning, and thus far no attempt has been made to use the improved flushing system. The cleanings are removed in wagons owned by the city and disposed of by dumping upon the various rubbish dumps. None of this class of material is received at the incinerating plant.

NIGHT SOIL.

The removal of this class of waste is well organized and appears to be satisfactorily accomplished. Several licensed collectors are engaged in the work, and all of the material is disposed of under city regulation. Until recently it has been burned at the garbage crematory at the expense of the collector.

Suitable watertight wagons which keep the waste material enclosed from the air are used and removal is permitted during the day. No complaints from nuisance have been registered.

STEUBENVILLE.

The city of Steubenville is located in the extreme eastern portion of Jefferson County on the Ohio River, which flows in a general southerly direction, forming the eastern corporation line of the city.

The area of the corporation is three square miles, the city covering a narrow strip of land between the river and the hilly portion of the country lying immediately west. The topography within the city is rather flat, but in all directions the surrounding country is very hilly. The population of Steubenville, according to the 1910 Federal census, is 22,391. The growth in population since 1890 is shown in the accompanying table. It will be seen that the growth during the decade 1900 to 1910 has been very marked, and this has resulted almost entirely from the development of large manufacturing industries.

Year.	*Population.*	*Percentage. Increase.*
1890	13,394	....
1900	14,349	7.1
1910	22,391	56.0

Steubenville is now an important manufacturing city and has large industries devoted to iron, steel and clay manufacturing.

In municipal improvements the city has made considerable advancement. It has a public water supply obtained from the Ohio River and furnished without purification; a fairly complete system of sewers; fifteen miles of paved streets; and other minor improvements.

The city owns and operates a crematory for the disposal of garbage and dead animals, but collections are made by a contractor. There is no municipal department for the collection of rubbish and ashes, which is carried on independently. The city maintains a street cleaning department, which is operated under the public service department.

GARBAGE.

Previous to 1907, the problem of collection and disposal of garbage was given but little attention by the city authorities. The collections were made by miscellaneous scavengers and the material was disposed of by dumping or feeding to swine. A large portion of the garbage was improperly disposed of by dumping along the banks of the Ohio River, and serious nuisances resulted, which caused frequent complaints on the part of the citizens. The unorganized system of collection and improper method of disposal became entirely unsatisfactory for the needs of the growing city, and it became necessary to place the work on a more substantial basis.

During the year 1907, the city erected a garbage incinerator for the

disposal of all classes of wastes. At this time an improvement was also brought about in the collection system. The city purchased two collection wagons, but did not attempt the organization of a municipal collection department. Instead, a contract for the collection of garbage was awarded to an independent scavenger, who has carried on the work since 1907.

By the terms of the contract the city supplies the collection wagons, the contractor supplying all other equipment and labor necessary for the work. The contractor also pays the city $150 per year, and is permitted to charge 10 cents to the householder for the removal of each can of garbage. For final disposal the city makes the following charges to the collector:

Garbage	10 cents per load
Large animals	$2.00 each
Night soil	4.00 per load

Other miscellaneous scavengers operating without license or contract with the city are charged double the above fees.

The equipment owned by the city for the collection of garbage and its disposal consists of two collection wagons and a crematory. The collection wagons are of the type manufactured by the United States Sanitary Company, of Washington, D. C., are of steel construction, and have capacities of 2.4 cubic yards each. The bodies are supported upon a bearing and may be revolved in dumping.

Collections are made by the contractor in all portions of the city at weekly intervals. The financial success of the work is dependent upon frequent and complete covering of the city, and this results in very efficient collection service.

Method of Disposal.

Description of Incineration Plant. The crematory is located on the west bank of the Ohio River, some 1,500 feet southeast of the central business portion of the city and about ½ mile north of the southern corporation line. The locality surrounding the plant is thickly built up and is given over partly to business and partly to residential purposes.

The building housing the furnace is a substantially constructed brick structure, two stories in height and about 40 by 50 feet in plan. The lower or ground floor contains the furnace proper, while the upper story is used as a dumping floor and is reached by means of an inclined roadway. The furnace is of the type known as the Lewis and Kitchen incinerator, and was built after plans of Frank P. Smith, of Chicago, consulting engineer. The plant was placed in operation in June, 1907.

The installation consists of two cells, each 27 feet long, 6 feet wide and 10 feet high to the crown, inside dimensions. The cells are constructed of brick, are lined with fire brick, and the entire furnace is enclosed by a shell of cast iron plates bolted together and stayed by means

of columns which also support the dumping floor above. The cells are placed side by side and are connected at one end by means of an arched opening 3 feet in width and 4 feet in height. At the other end each cell connects with the stack through flues provided with dampers placed in order that the draft might be drawn to the furnace in either direction. The furnace was designed in this way in order that while combustion was taking place in one of the cells the damper in the stack flue at the end of that cell might be closed and the draft be conducted through the arched opening to the other cell and hence to the stack. By this means the garbage could be dumped into each of the cells on alternate days and the heated products of combustion from the burning cell could be used to effect a drying of the fresh garbage in the other cell. This method of operation has never been successful, and it has been necessary to operate each cell independently with a direct draft to the stack. It should be noted that the latter method of operation introduces conditions which materially affect the action of the furnace. The arched opening between the cells permits large volumes of cold air to enter the burning cell from the idle one, and this prevents the production of high temperatures.

Four charging holes for the introduction of garbage, dead animals and rubbish are placed in the crown of each cell. When dumped through the charging hole the material rests on so-called primary grates, where drying and subsequent burning takes place. These grates, excepting those directly over the fire boxes, are made of arched fire clay blocks with circular openings 8 inches in diameter, provided to permit the passage of air through the grates, as well as to allow the stoking of garbage on to the evaporating and combustion floor beneath. The grates extend across the width of the furnace and are placed in sets of three each, those under the charging holes being placed at a distance of about 3 feet 4 inches below the crown of the furnace, while on either side, adjacent to the fireboxes, the grate bars are 1 foot 8 inches lower.

The arrangement as shown by a longitudinal section of the cell represents a staggered line, the upper and lower grates alternating. When the furnace was originally built, the grates directly over the fireboxes were constructed of iron pipe and designed to be air-cooled by means of a flue connection to the stack. The use of these grates has been abandoned, however, as the air-cooling feature failed to prevent the burning out of the metal.

Three fireboxes in each cell are provided for the combustion of auxiliary fuel. They are located at either end and at the middle of the cells. Each firebox has dimensions 3 by 6 feet, and a grate area of 18 square feet. The grates are at a depth of 10 inches below the evaporating and combustion floors, over which the products of combustion pass. These floors are constructed of perforated steel plates, and it is here that most of the garbage is burned. The perforations were designed to permit the passage of air from an air blast to be introduced in the space

below the floors. The installation at Steubenville has never been equipped with an air blast. The perforations were also expected to act as a means of removing water from the garbage, and the space beneath is provided with a gutter for the drainage of the liquors into a sewer which empties into the Ohio River. The draining result is not accomplished, however, as the perforations in the floor have become completely clogged with clinkers and ashes.

Access for stoking the garbage on the primary grates and also upon the combustion floors beneath is provided by two rows of doors extending along the sides of the cells.

The gases from the furnace pass through a large underground rectangular flue into a circular stack 100 feet high and 4 feet in diameter. At the base of the stack within the building is placed a furnace designed for raising the temperature of the gases from the furnace to a sufficiently high degree to avoid odors. This furnace is, however, never used.

Method of Operation. The furnace is operated from 6:30 A. M. to 5:30 P. M. during six days each week. The cells are used independently, being alternated each day. By this procedure it is necessary to start with a cold furnace containing the garbage to be destroyed each morning. The refuse is dumped into the furnace immediately upon its arrival at the plant, no storage place being provided. The dumping of a wagon load of garbage requires that the furnace remain open about fifteen minutes. This creates no large heat loss, however, as the garbage is always introduced into the idle cell and not burned out until the succeeding day. Rubbish is either dumped into the burning cell or stored upon the floor and added to the cell during the latter portion of the day.

After the fires are lighted each day the heating of the cell takes place very slowly, and at no time throughout the day are high temperatures attained. Needless to say, the gases leaving the stack are odor laden and under certain atmospheric conditions, the odors manifest themselves in the central business portion of the city.

The garbage resting upon the primary grates is dried and partially burned in that position, but its destruction is completed upon the evaporating and combustion floor or directly upon the fuel fires. In the latter portion of the day's run the dried garbage is frequently stoked, being worked gradually toward the fuel fires, where it is finally consumed.

The ash produced by the furnace usually has the appearance of having been incompletely burned. It is of a brownish-gray color and oftentimes contains bits of unburned material. The odor of the ash is not especially objectionable, but can be detected. The material is disposed of by dumping along the bank of the Ohio River a short distance from the plant.

Character and Quantity of Refuse Burned.

The refuse received at the plant is principally kitchen garbage. Mixed garbage and rubbish from groceries, commission and jobbing

houses, etc., also constitutes a portion of the material, and occasionally dead animals are delivered at the plant.

The garbage has been observed on but one occasion, at the time of the investigation herein described, September, 1909. At this time the garbage was very wet, contained a comparatively large quantity of rubbish, and its principal constituents were peelings and corn husks. In appearance it did not differ materially from the garbage of other Ohio cities.

The rubbish received for disposal is principally from business houses and very little household rubbish is disposed of in this manner. Dead horses and cattle are received regularly, although a number of these animals are also removed and disposed of by a private company engaged in the rendering business.

In table No. 76 are given monthly records of the quantities of garbage collected during 1908, 1909 and 1910; and in table No. 77 are yearly totals of wastes received at the plant. It will be noted that the increased efficiency of the collection service has resulted in a marked increase in the quantities for 1910 over those of the preceding years. During the summer months it will be seen that the collections are at their maximum, as is generally observed where efficient work is done.

TABLE NO. 76.

QUANTITIES OF GARBAGE COLLECTED.

	1908				1909				1910			
	Cu. Yds.	Tons.	Cu. Yds. per Capita.	Lbs. per Capita.	Cu. Yds.	Tons.	Cu. Yds. per Capita.	Lbs. per Capita.	Cu. Yds.	Tons.	Cu. Yds. per Capita.	Lbs. per Capita.
January	147	92	.0071	8.8	130	81	.0060	7.5	233	146	.0104	13.0
February	151	94	.0073	9.1	84	53	.0039	4.9	202	126	.0090	11.2
March	167	104	.0080	10.0	113	70	.0052	6.5	247	154	.0109	13.7
April	173	108	.0083	10.4	137	86	.0063	8.0	254	159	.0113	14.2
May	95	59	.0046	5.7	147	92	.0068	8.5	374	234	.0167	20.9
June	145	91	.0070	8.7	219	137	.0101	12.7	305	191	.0136	17.0
July	159	99	.0076	9.5	242	151	.0112	14.0	352	220	.0157	19.7
August	117	73	.0056	7.0	219	137	.0101	12.7	374	234	.0167	20.9
September	45	28	.0022	2.7	170	106	.0079	9.8	257	161	.0115	14.4
October	116	72	.0056	6.9	159	99	.0074	9.2	274	171	.0122	15.3
November	67	42	.0032	4.0	149	93	.0069	8.6	267	167	.0119	14.9
December	36	23	.0017	2.2	120	75	.0056	7.0	254	159	.0113	14.2
Total	1,418	885	.0682	85.0	1,889	1,180	.0874	109.4	3,393	2,122	.1512	189.4
Average	118	74	.0057	7.1	157	98	.0073	9.1	283	177	.0126	15.8

TABLE NO. 77.

TOTAL REFUSE RECEIVED AT PLANT.

1908-1910.

Year.	Number Loads.				Dead Animals.	
	Licensed Collection.	Unlicensed Collection.	Approx. Cu. Yds.	Approx. Weight* Tons.	Total Tons.	Tons.
1908	495	379	1,418	885	10	895
1909	786	.....	1,889	1,180	15	1,195
1910	1,414	.....	3,393	2,122	30	2,152

* Weight garbage, 1250 pounds per cubic yard.

Cost Data.

The total cost of the equipment of the city for removal and disposal of garbage was about $25,000, representing a present per capita cost of $1.12.

The cost of operation and maintenance of the crematory is given in table No. 78.

TABLE NO. 78.

COST OF GARBAGE DISPOSAL.

Year.	Salaries.	Fuel.	Incidentals.	Total.
1908	$900	$414	$647	$1,961
1909	900	326	404	1,630
1910	1,380	410	704	2,494

The unit costs based on the figures of the foregoing table, are given in table No. 79.

TABLE NO 79.

UNIT COSTS OF GARBAGE DISPOSAL.

Year.	Total Cost per Capita.	Total Cost per Ton Refuse.	Fuel Cost per Ton Refuse.	Labor Cost per Ton Refuse.
1908	$0.094	$2.21	$0.47	$1.02
1909	0.075	1.38	0.28	.76
1910	0.110	1.18	0.19	.65

It will be noted that a large reduction has taken place in the unit costs of disposal, and this has been due principally to the increased quantities of material burned, the furnace being thus operated at more nearly its rated capacity and without a corresponding increase in cost.

The receipts of the garbage department for the years 1908 to 1910 are presented in table No. 80.

TABLE NO. 80.

RECEIPTS OF GARBAGE COLLECTION AND DISPOSAL.

Year.	Collection Contract.	Fees for Burning Refuse.	Total.
1908	$150	$160	$310
1909	150	150	300
1910	150	202	352

RUBBISH AND ASHES.

The collection of household rubbish, ashes, etc., is given very little attention and is not carried on by the city or under its supervision. Miscellaneous scavengers remove this class of refuse and dispose of it by dumping, or, if it be of a combustible nature, it may be disposed of at the garbage crematory. Grocers, jobbers, etc., remove their own rubbish, which is usually of a combustible nature, and this is received without charge at the plant.

The removal of household rubbish and ashes is very irregular and infrequent, and as the expense is wholly upon the householder the work

is incomplete. There has been considerable complaint due to the dumping of the material along the banks of the river. This has resulted in very unsightly conditions, although no decided nuisance due to odors has been created.

STREET CLEANING.

In order to maintain the paved streets of the city in a cleanly condition, a department with a small equipment is maintained. The work is carried on under the direction of the public service department, a superintendent being employed in immediate charge of the work.

The equipment of the department includes one machine sweeper, five horses, four white wing outfits, one dump wagon, and a stable for housing the equipment.

The streets are cleaned by two methods, namely, machine sweeping and hand cleaning. The former is carried on entirely at night, and thus to a large extent the objection to the creation of dust is removed. Hand cleaning is carried on during the day on the principal streets of the city. The frequency of cleaning varies in different sections of the city and at different seasons of the year, but an attempt is made to clean all streets every two weeks, those in the business section being covered more frequently.

The dirt removed from the surface of the streets is carted to conveniently located dumping grounds along the river bank, where it is disposed of without causing complaint.

The cost of street cleaning averages $1400 per month or $16,800 per year, representing a cost of $0.75 per capita and $1120 per mile of streets. These unit expenditures are excessive in comparison with those of the larger cities of the state.

ZANESVILLE.

The city of Zanesville is located in the central portion of Muskingum County on the Muskingum River, at its point of confluence with the Licking River. The surrounding country is hilly, but the larger portion of the city itself is located upon rather flat ground.

The population of the city according to the Federal census for 1910, is 28,026. The following table gives the recent census reports:

Year.	*Population.*	*Percentage. Increase.*
1890	21,009	....
1900	23,538	12.0
1910	28,026	19.1

It will be seen that the city has for the past twenty years experienced a steady but not a rapid growth. Owing to its rather favorable shipping facilities, Zanesville is an important manufacturing center, its largest plants being devoted to the clay industry. The city is provided with a number of municipal improvements, including a public water supply; sewerage; paved streets; municipal collection and disposal of garbage; and street cleaning.

City wastes disposal and street cleaning are carried on under the department of public service, the work being handled by two sub-departments, which care for the collection and disposal of garbage and for the cleaning of the streets. No municipal rubbish and ashes collection department at present exists.

GARBAGE.

Previous to 1907, the collection and disposal of garbage was carried on by independent scavengers, who made irregular and rather infrequent collection throughout the city and disposed of the material by burying it or feeding it to swine in the surrounding country. This system of collection and disposal was very unsatisfactory owing to the careless and unsystematic manner in which it was carried on, and it became necessary for the city to make improvements in this branch of public work.

In the early part of 1907, the city installed a refuse destructor for the disposal of garbage and rubbish collected within the city. For some time after this plant was built, however, no important changes were made in the collection system, and the independent scavengers continued to collect garbage and dispose of it as they saw fit. All of the garbage was removed to the surrounding country, as was the case before the crematory was built; and until the early part of 1909 only rubbish was received for destruction. During the year 1908 the city made an effort

to organize and improve garbage collection by awarding a contract to a collecting company. The company received $2,600 for the work during the year and disposed of the waste material almost entirely by feeding to hogs.

In the spring of 1909 the city instituted municipal collection of garbage, disposing of it in the crematory, and this method remains in force at the present time. With the adoption of municipal collection nearly all of the independent scavengers ceased to collect garbage, but have continued the removal of rubbish. The garbage collection and disposal are under the direct supervision of the director of public service, who hires such labor and assistance as is required.

The equipment of the garbage department includes three collection wagons, horses, stables, and a garbage crematory. The collection wagons are of 2 yards and 1½ yards capacity, are watertight and provided with tightly fitting covers. They create no nuisance in passing through the streets.

Collections are made in all portions of the city at intervals of about two weeks, the frequency varying somewhat according to the remoteness of the districts. The present collecting system is not entirely satisfactory owing to the fact that insufficient funds are available for the proper carrying on of the work. It has, however, proved to be a vast improvement over the old unorganized system and in time will probably develop a higher state of efficiency.

Method of Disposal.

Description of Plant. The garbage crematory is located in the central portion of the city on the north bank of the Muskingum River. The site of the plant is within a few blocks of the business section, and is in the center of a thickly built up locality. The furnace is built in the pump pit of the old water works station. The building is a one-story brick structure, which also serves as a barn for the equipment of the garbage collection and street cleaning departments. It is 28 feet by 72 feet in plan, and is arranged so that the collection wagons may be driven through the building and directly over the furnace. The pit in which the furnace is located is about 44 feet long, 19 feet wide and 17 feet deep.

The installation consists of a main incinerating furnace and a so-called gas consuming furnace. The main furnace is constructed of a shell of ¼-inch steel plates, the sides and ends being lined with fire brick. The furnace is 10 feet 10 inches in length, 9 feet in width, and 10 feet in height above the grates, inside dimensions. Directly over the furnace and forming the top is a rectangular boiler or water jacketed crown, 11 feet 10 inches by 11 feet 7 inches by 1 foot 6 inches, constructed of ⅜-inch and 5/16-inch steel plates, and stayed in all directions with 1¼-inch bars spaced to withstand a pressure of 100 pounds.

Openings for the introduction of the material to be burned penetrate the dumping floor over the furnace. Two circular openings extend through the crown and are intended for the admission of miscellaneous rubbish and garbage containing a medium moisture content. On either side of the furnace and in line with the circular openings are rectangular steel hoppers, provided for the admission of wet garbage containing a large amount of water which will drain off. The bottoms of these hoppers are constructed with a perforated steel strainer, through which the liquid passes into a drain pipe leading to the evaporating pan below the furnace. When thoroughly drained the garbage can be discharged on to the upper tubular grates by the operation of sliding steel doors at the bottom of the hoppers. At the front of the furnace is a steel chute discharging directly on to the lower grates and designed for the dumping of dry and easily combustible refuse. The tops of all openings are flush with the dumping floor above the furnace and are provided with well constructed steel doors.

On the interior of the furnace are water-cooled tubular grates set to form an inverted "V" with an angle of about 40 degrees, the vertex of which is in the upper-central portion of the furnace. These grates are constructed of 1½-inch pipes and are set on 9-inch centers. The upper ends connect with the crown above and the lower ends connect with 8-inch headers extending along either side of the furnace. These headers are also connected with the crown by means of pipes outside the furnace at each corner. Water from the city mains is supplied to the headers for circulation through the grates and crown and the steam generated is used for the steam spray in the gas consuming furnace, as will be described, the excess being allowed escape into the atmosphere through a relief valve.

The lower or main grates of the furnace are constructed of cast iron bars 4 feet 6 inches long and 5 inches wide, perforated with ½-inch holes staggered at about ¼-inch on centers. About 50 per cent. air space is thus provided. Below these grates is an ash pit depressed 6 or 8 inches below the floor level. This ash pit also acts as an evaporating pan, receiving the liquids draining from the garbage in the furnace and side hoppers. A steam space beneath the ash pit assists in furnishing the heat necessary for evaporation. Doors are located in the ends and sides of the furnace, giving accessibility to the upper and lower grates.

The products of combustion pass from the furnace to the gas consuming furnace through two horizontal circular flues, each 2 feet 6 inches in diameter, which lead from one end of the furnace near the crown. A checkerwork of fire brick is placed between the furnace and the flues and serves to mix the gases and assist in completing combustion.

The gas consuming furnace through which the gases pass before entering the stack consists of a steel shell lined with fire brick. Its outside dimensions are 9 feet in width, 10 feet 7 inches in length, and 6 feet

2¼ inches in height. It is divided longitudinally into two parts by a wall of fire brick, so that the gases from each of the circular flues pass through the gas consuming furnace independently and join in the stack. Fire walls are built across the two parts of the furnace in such a way that the gases are first conducted downwards over a pan of water, then horizontally between updraft and downdraft fires, then upward and again downward through a steam spray and over a second pan of water, at which point they enter the stack. The water areas and steam spray are designed to remove particles of solid matter carried in suspension in the flue gases, and the fires are intended to raise the temperature of the gases sufficiently to complete their combustion and remove odors contained.

After passing the gas consuming furnace the products of combustion enter a stack 160 feet high by 5 feet inside diameter. The stack is constructed of riveted steel plates lined with fire brick to a height of 40 feet above the surface of the ground. It is enlarged at the base and set on a heavy stone and concrete foundation. No dampers for the regulation of the draft through the main furnace or the gas consuming furnace are installed.

Method of Operation. The operation of the incinerating furnace at Zanesville is necessarily intermittent, owing to the fact that an insufficient amount of garbage is received to permit of continuous operation according to the prescribed methods of the Decarie Incinerator Company.

During the summer season of the year six loads of garbage or from 7½ to 8 tons are delivered daily by the municipal wagons, and varying quantities of mixed grocery, meat market, household garbage and rubbish, wood, paper and other rubbish from wholesale and retail stores throughout the city. Each of the three municipal garbage wagons arrives with its first load late in the morning and the load is immediately dumped into the furnace. The second loads, however, arriving late in the afternoon, are kept in the wagons until the following morning, when they are dumped just before the fires are started.

At 5:30 each morning the furnace and ash pit are thoroughly cleaned in preparation for the day's run. Twenty-five to 30 bushels or 2,000 to 2,400 pounds of coal are then spread in an even layer of about 5 or 6 inches in thickness over the grate bars. Above the layer of coal about 1,800 pounds of cord wood are placed, making a layer of from 18 to 24 inches in thickness. Immediately above the coal at each of the lower fire doors at the ends the furnace are placed barred staves, used to ignite the fires. About 200 pounds of kindling wood selected from loads of refuse are dumped through the combustible chute at the front of the furnace. With these preparations the furnace is ready for the reception of garbage. It should be noted that the quantity of coal and wood placed in the furnace is varied to meet special conditions. The figures given apply to the ordinary conditions of operation.

Before the fires are ignited in the incinerating furnace, however, the fires in the gas consuming furnace are started in order to bring the gas consuming furnace to a high temperature before combustion gases reach it. Only the lower or updraft fires on each side of the furnace are employed.

The extent to which the fires in the gas consuming furnace accomplish the complete combustion and deodorization of the gases from the main furnace is uncertain. During the early part of a burn the fires in the gas consumer are easily kept in good condition and no doubt accomplish their purpose; but as the temperature increases the draft becomes intense and it becomes difficult to maintain hot fires in the gas consumer. The air excess in these fires is very great and a consequent cooling takes place, defeating the object desired.

At the time that the first load of garbage is dumped, usually at about 7:00 A. M., the fires in the main furnace are started. The three loads which have stood in the wagons since the previous afternoon are then dumped through the circular openings at the top of the furnace. The side hoppers which should properly receive this class of refuse have never been used owing to the difficulty encountered in operating the sliding doors. In dumping the garbage the larger portion rests upon the tubular grates in a pile at the sides and half-way between the ends of the furnace. A large amount, however, passes directly through the grates and blankets the fuel bed below. The water contained in the garbage drains through the fuel bed and grates for several hours after dumping, greatly retarding the progress of the fire. After the fires are burning brightly the stoking of the garbage is actively attended to in order to facilitate and hurry the drying process. Except at the end of a burn, combustion takes place actively only at the ends of the furnace near the lower fire doors and all of the garbage must be pulled to these points to accomplish its destruction. The central portion of the furnace is totally dead except in the last stages of the day's run. Upon the arrival in the morning loads between 10:00 and 11:00 A. M., they are immediately dumped into the furnace, increasing the size of the pile in the central portion and greatly retarding the progress of the fires toward that portion of the furnace. At various times throughout the morning and the early part of the afternoon small loads of a miscellaneous character are received and dumped. These loads probably have little effect on the furnace either in assisting or retarding the fires. With the progress of the burning the fuel bed is burned out at the ends of the furnace where combustion is most active, and coal is added from time to time at these points to keep a bright fire.

Steam pressure is produced in the crown from three to four hours after the fires have been started, depending on the nature of the garbage as to moisture and combustibility. The maximum pressure reached dur-

ing a day's run varies with the intensity of combustion. Ordinarily a maximum of about 40 pounds is obtained toward the end of the day and at times pressures as high as 70 pounds have been reached.

Frequent stoking of the garbage is necessary during the entire day until the volume has been reduced to a level below the tubular grates. At this time the material in the furnace is almost completely dried and is easily combustible. It therefore burns rapidly without requiring frequent stoking.

The ash produced is usually well burned and possesses little odor. The condition of the ash, however, is dependent upon the quantity of fuel originally introduced, as well as upon the attention of the operator to the firing and stoking of the furnace. Unless sufficient fuel is used and careful attention given, the ash will not be completely consumed. The ashes are removed from the furnace each evening and the furnace is allowed to cool until the following morning. At intervals the ashes are removed in wagons and disposed of by dumping.

The operation of the plant gives rise to objectionable odors which are noticeable in the central business portion of the city. The production of odors seems to be independent of the operation of the gas consuming furnace, and complaint is made at all times.

During the year 1910 the fuel used in the destruction of the refuse totaled 400 tons and 90 cords of wood (equivalent to 126 tons). Reducing the fuel to equivalent coal, a total of 456 tons were used. On the basis of 1070 tons of garbage destroyed, the coal consumption was 760 pounds equivalent coal per ton of garbage destroyed.

Character and Quantity of Refuse Destroyed.

The wastes received at the incinerating plant are of two classes, namely, garbage collected by the city, and mixed refuse privately brought to the plant. Garbage constitutes the bulk of the material received, amounting to about 80 per cent. of the total, while the mixed refuse, which is somewhat irregular, totals about 20 per cent.

The municipal garbage department has neglected the maintenance of proper records of the quantities of garbage and other refuse received at the plant for destruction. During 1910, however, records of these quantities were kept, and these are presented in table No. 81. It will be noted that the maximum garbage collection occurs in August and September, the minimum falling in the winter season, when the department work is very light. The quantities on the unit basis are much smaller than obtain in the larger cities of the state, indicating incomplete collection.

TABLE NO. 81.

QUANTITIES OF GARBAGE AND REFUSE COLLECTED, APRIL TO DECEMBER, 1910.

	Garbage.				Mixed Refuse.		
	Number Cu. Yds.	Approx. Weight, Tons.	Cu. Yds. per Capita.	Pounds per Capita.	Number Loads.	Approx. Weight, Tons.	Approx. Total Weight Wastes, Tons.
April	166	104	.0059	7.4	69	17	121
May	162	101	.0058	7.3	86	22	123
June	188	118	.0067	8.4	105	26	144
July	198	124	.0069	8.6	141	35	159
August	243	152	.0087	10.9	139	35	187
September	240	150	.0086	10.8	124	31	181
October	213	133	.0076	9.5	111	28	161
November	166	104	.0059	7.4	100	25	129
December	134	84	.0048	6.0	116	29	113
Average per month.	190	119	.0068	8.5	110	28	147

NOTE: — Tonnage estimated as follows:
Garbage 1250 pounds per cubic yard.
Mixed refuse 500 pounds per load.

Cost Data.

In tables No. 82 and No. 83 are given itemized costs of collection and disposal of garbage respectively, for 1908, 1909 and 1910. The total costs are given in table No. 84. It will be seen that the cost of collection has been reduced by the adoption of municipal collection, although it should be noted that the costs do not include new equipment or fixed charges on the investment.

TABLE NO. 82.

COST OF GARBAGE COLLECTION.

	By Contract.	Salaries.	Incidentals.	Maintenance.	Total.	Cost per Capita.
1908	$2,600	.....	.....	.....	$2,600	$0.096
1909	96	$1,664	$53	$653	2,466	0.090
1910	.....	1,472	473	607	2,552	0.091

TABLE NO. 83.

COST OF GARBAGE DISPOSAL.

	Salaries.	Fuel.	Incidentals.	Total.	Cost Per Capita.
1908	$1,450	$147	$252	$1,850	$0.068
1909	1,941	638	650	3,229	0.117
1910	1,676	759	663	3,098	0.110

TABLE NO. 84.

TOTAL COST OF GARBAGE COLLECTION AND DISPOSAL.

	Cost of Collection.	Cost of Disposal.	Total Cost.	Total Cost per Capita.
1908	$2,600	$1,850	$4,450	$0.164
1909	2,466	3,229	5,695	0.207
1910	2,552	3,098	5,650	0.201

On the basis of 1200 tons of garbage collected during 1910, the unit costs were as follows:

Collection:	Total cost per ton		$2.13
Disposal:	Total cost per ton		2.58
	Fuel, cost per ton	$0.63	
	Labor, cost per ton	1.40	
	Incidental, cost per ton	.55	

RUBBISH AND ASHES.

No provision is made by the city to care for the removal of rubbish and ashes, and this work is left entirely to independent scavengers. The city is incompletely covered and the collections are quite irregular. The removal of rubbish from the central business portion of the city is privately done and the waste material is disposed of by burning at the garbage crematory.

The rubbish and ashes of household origin are disposed of by dumping at various points in the outskirts of the city. The combustible portions of the material are received and destroyed without charge at the

garbage crematory, but only small quantities are disposed of in this manner.

STREET CLEANING.

The department of street cleaning is under the general supervision of the department of public service. The equipment of the department is small, which does not permit as frequent cleaning as should obtain. The streets are cleaned by machine sweeping and hand cleaning. The work of the department is irregular, being almost entirely suspended during the winter months. During 1909 $7,200 or $0.26 per capita was expended for street cleaning. This figure is much less than is usual in the larger cities of the state.

The methods of street cleaning are not satisfactory, owing to the attendant dust nuisance which is common when the machine sweeping method is used. All material removed from the streets is removed in wagons and disposed of at convenient dumping grounds. Its disposal by this means is unobjectionable.

APPENDIX II.

THE DISPOSAL OF GARBAGE BY INCINERATION IN OHIO.

DESCRIPTION OF FURNACE TESTS ON CREMATORIES AT

CANTON.

MANSFIELD.

MARION.

STEUBENVILLE.

ZANESVILLE.

THE DISPOSAL OF GARBAGE BY INCINERATION IN OHIO.

In six of the fourteen cities of the state whose populations are between 20,000 and 80,000, garbage is disposed of by burning. In the other eight cities the material is principally dumped on land or buried. In only one city of less than 20,000, namely, Marion, is a garbage crematory maintained. A list of the Ohio cities using incineration as a method of disposal is as follows:

City.	*Population*, 1910.
Marion	18,262
East Liverpool	20,387
Mansfield	20,768
Steubenville	22,391
Zanesville	28,026
Canton	50,217
Youngstown	79,066

Studies of this method of disposal were carried on in each of these cities excepting East Liverpool and Youngstown, and one or more furnace tests conducted during the study.

METHOD OF CONDUCTING FURNACE TESTS.

In studying the disposal of garbage by incineration in the various cities in Ohio employing this method, the principal object was to secure data to determine the results obtained by the usual methods of operation employed at the various plants. Special conditions of operation were introduced for but one test, at Canton, July 30, 1909, when the effect of uniform introduction of garbage into the furnace was studied. It was not expected that the results of the studies would furnish data for comparison of the different types of furnace represented in the state, and it will be seen that accurate comparison is difficult when it is considered that variations in the conditions attending the tests introduce factors which are independent of the type of furnace. No set of standard conditions to apply to the tests on all of the plants was adopted, therefore, but the local conditions at each plant were undisturbed for the tests. The results of the studies are therefore largely an indication of the operation rather than a basis for comparison of the different types of furnaces.

The satisfactory disposal of garbage by burning from the standpoint of creation of a nuisance is largely dependent upon the temperature maintained within the combustion cell; and temperature measurements therefore constitute the most important observations of the tests. The temperatures produced are in a large degree dependent upon the con-

struction and condition of the furnace, but are also greatly affected by the method of operation.

In general the furnace tests consisted in burning a known quantity of garbage and other wastes and in studying the action of the furnace by means of observations made during the tests. The principal observations included:

1. The quantity and character of refuse burned and the time and method of introduction into the furnace.
2. The quantity and kind of fuel used and methods of firing.
3. Frequency and method of stoking.
4. Temperatures: Furnace room; over fires; in garbage cell; and in flues and stack.
5. Flue draft.
6. Flue gas analyses.
7. Appearance of gases leaving stack; odors at plant and in vicinity.
8. Quantity and character of ash produced.

Samples were also collected and shipped to the laboratory at Columbus for analysis as follows: Garbage as received; fuel; fuel ash; and garbage ash.

DESCRIPTION OF APPARATUS USED FOR TESTS.

For high temperature measurements two platinum ribbon pyrometers measuring up to 3000 degrees Fahrenheit were employed. These instruments were used for reading temperatures within the combustion cell. For reading temperatures below 800 degrees a low temperature pyrometer was used. Flue temperatures were obtained principally by the use of this instrument. These pyrometers were manufactured by Edward Brown and Son of Philadelphia.

Flue and stack measurements were made by means of a draft gage, manufactured by the Ceramic Supply and Construction Company of Columbus. An Orsat apparatus and necessary appliances were used for the analysis of flue gas.

The above instruments were packed in cases so as to permit of shipping and were transported without injury to the different cities when required. Other necessary apparatus, such as tubes for sampling the flue gas, scales for weighing fuel, a mixing board for preparing samples of garbage, etc., were provided at each furnace.

CO-OPERATION OF CITY OFFICIALS AND KEEPING OF RECORDS.

One of the advantages of the study recognized during its progress was that resulting from securing the co-operation and interest of city officials in the subject of garbage disposal. In each of the cities visited hearty co-operation and assistance were given in conducting the tests, and in three of the cities the practice of keeping accurate records of operation was instituted. In the other two cities fairly satisfactory records were also maintained.

DESCRIPTION OF FURNACE TESTS.

In the following are presented detailed descriptions of the tests conducted at the various furnaces. Descriptions of each furnace together with attending conditions of the character and collection of wastes, method of operation, etc., have been presented in a previous portion of this report and will assist in interpreting the results of the tests.

The following is a list of the cities and types of furnaces used, and is also the order in which the descriptions of the test are presented.

City.	*Type of Furnace.*
Canton	Dixon.
Mansfield	Dixon.
Marion	Walker.
Steubenville	Lewis & Kitchen.
Zanesville	Decarie.

CANTON.

Three tests were conducted at the garbage crematory at Canton on July 29 and 30, 1909, and February 2 and 3, 1910. In the first test both cells of the furnace were used and the ordinary methods of operation were employed. For the second test one cell was used and special conditions introduced to learn the effect of uniform introduction of garbage into the furnace. During the third test one cell was used and ordinary operating conditions prevailed. In table No. 85 will be found the items of particular interest pertaining to the conditions of the tests and the results accomplished.

Tests of July 29, 1909.

During this test both cells of the crematory were used. In preparation of the test the cells were cleaned thoroughly and allowed to cool to a temperature of about 100 degrees F. Throughout the test the fireman regularly employed at the plant was allowed to follow his usual methods of operating the furnace and frequent observations were made for the purpose of studying the results obtained under the ordinary operating conditions. The principal observations are presented in tables No. 86 and No. 87.

TABLE NO. 85.

DATA ON CREMATORY TESTS AT CANTON.

Date.	July 29, 1909.		July 30, 1909.	Feb. 2-3, 1910.
Duration of test (hours)	22.0		5.25	30.5
Cells used for test	No. 1	No. 2	No. 2	No. 2
Quantity of garbage destroyed (lbs.)	5,155	3,585	5,880	11,620
Time required to burn garbage (hours)	22.0	18.5	4.5	30.5
No. hours during which coal was used	10.0	6.5	5.5	14.0
Quantity of garbage destroyed per hour (lbs.)	234	193	1,307	380
Quantity of garbage destroyed per hour per sq. ft. grate area	1.95	1.61	10.9	3.17
Quantity of garbage destroyed per hour during use of coal	515.5	358.5	1,070	830
Quantity of garbage destroyed per hour duing use of coal per sq. ft. grate area	4.30	2.99	8.92	6.92
Average percentage moisture in garbage	75.4	75.4	77.3	73.0
Weight of ashes remaining (lbs.)	603.5	452.5	478.5	472.0
Per cent ashes of total weight of garbage	11.7	12.6	8.1	4.1
Quantity of coal used (lbs.)	2,042	1,565.5	2,071	3,905
Coal used per hour of firing (lbs.)	204	241	376	280
Coal used per hour per sq. ft. grate area (lbs.)	6.2	7.4	10.3	7.6
Coal used per hour per ton garbage (lbs.)	792	872	670	672
Heating value of coal (B. T. U.)	10,983.	10,983.	10,983.	11,748.
Heating units in coal per pound garbage (B. T. U.)	4,349	4,789	3,679	3,690
Fuel cost per ton of garbage destroyed	$0.73	$0.81	$0.65	$0.62
Average temperature combustion chamber, Deg. F.	522	553	1,127	972
Max. temperature combustion chamber, Deg. F.	1,065	1,000	1,595	1,335
Average flue temperature, Deg. F.	512	567	852	567
Average furnace room temperature, Deg. F.	80	80	90	50

TABLE NO. 86.-

OBSERVATIONS DURING CREMATORY TEST AT CANTON.

Cell No. 1. July 29, 1909.

Period.	Temp. Upper Fire.	Temp. Lower Fire.	Aver. Temp. of Furnace.	Flue Temp.	Draft.	Flue Gas Analyses.			Garbage Introduced.		Remarks.
						CO_2.	O_2.	CO.	Weight (lbs.)	Time.	
10:30–11:15A	.....	.....	431	.....	.31	.....	.....	.....	1,530	10:15 A. M..	Fires started at 10:30 A. M.
11:30A–12:00N	.....	.....	713	.....	.31	No flue gas analyses made owing to failure of Orsat apparatus.					
1:00–1:30P	850	880	442	.....	.28						
2:00–2:30P	1,510	780	328	340	.27	.....	.....	.....	135	2:00 P. M...	
3:00–3:30P	790	990	306	385*	.....	.....	.....	.....	2,140	3:30 P. M...	
4:00–4:30P	1,300	1,980	552	470*	.30	.....	.....	.....	.....	.....	
5:30–6:00P	.....	.....	570	.....	.34	.....	.....	.....	1,350	5:00 P. M...	Fires banked at 5:40 P. M.
9:00P	470	1,330	.....	420	.26	1.0	21.2	0	.....	.....	
11:30–12:00P	540	940	230	330	.22	0.7	21.2	0	.....	.....	
July 30th.											
7:00A–7:30A	1,430	1,880	580	775	.35	5.8	14.6	0	.....	.....	Fires started at 5:30 A. M.
8:00A	1,400	1,880	1,065	875	.40	4.8	14.6	0	.....	.....	Fires drawn at 8:30 A. M.
Average	1,036	1,332	522	512	.30	.....	.....	.....	.....	.....	.....

* Temperature in stench consuming furnace.

TABLE NO. 87.

OBSERVATIONS DURING CREMATORY TEST AT CANTON.

Cell No. 2. July 29, 1910.

Period.	Temp. Upper Fire.	Temp. Lower Fire.	Aver. Temp. of Furnace.	Flue Temp.	Draft.	Flue Gas Analyses.			Garbage Introduced.		Remarks.
						CO_2.	O_2.	CO.	Weight. (Lbs.)	Time.	
2:40-3:00 P. M...	630	1,110	318	385*	.25	.....	.....	.....	1,025	2:00 P. M.....	Fires started at 2:00 P. M.
3:30-4:00 P. M...	1,100	1,690	402	.....	.30	.....	.....	.....	.....	.....	
4:50-5:25 P. M...	1,740	1,870	598	470*	.34	.....	.....	.....	1,130	4:25 P. M.....	
7:10 P. M.....	670	1,430	.....	.....	.....	.....	.....	.....	1,430	5:30 P. M.....	Fires banked at 5:40 P. M.
9:45-10:00 P. M..	520	890	314	420	.24	1.0	21.2	0.0	.....	.....	
11:35-12:00 P. M..	390	620	270	345	.22	0.7	21.2	0.0	.....	.....	
July 30th.											
7:00 A. M.....	.....	.....	1,000	775	.34	.....	.....	.....	.....	.....	Fires started at 5:30 A. M.
7:30-8:00 A. M...	1,480	1,750	825	875	.36	5.8	14.6	0.0	.....	.....	
8:10-8:45 A. M...	1,860	1,870	700	700	.40	4.8	14.6	0.0	.....	.....	Fires drawn at 8:30 A. M.
Average	1,049	1,404	553	567	.30	.....	.....	.....	.....	.....	

* Temperature in stench consuming furnace.

Refuse Destroyed. During the test 5155 pounds of garbage were introduced into cell No. 1 and 3895 pounds into cell No. 2. The garbage was introduced into the cells as follows:

Cell No. 1.		Cell No. 2.	
Time.	Weight of Garbage.	Time.	Weight of Garbage.
10:15 A. M.	1530	2:00 P. M.	1025
2:00 P. M.	135	4:25 P. M.	1130
3:30 P. M.	2140	5:30 P. M.	1430
5:00 P. M.	1350		

The garbage received was entirely kitchen refuse consisting of vegetable, fruit and melon wastes, greasy water, and small amounts of rags, rubbish, etc. Its weight averaged 1205 pounds per cubic yard. A composite sample of the garbage received was collected and upon analysis was found to contain the following constituents:

Moisture	75.4%
Ash	2.80%
Combustible	21.80%
Ether extract	5.47%
Phosphoric acid (P_2O_5)	0.34%
Kjeldahl nitrogen	0.64%
Potash (K_2O)	0.28%
Calorific value (BTU)	2,335

The garbage was introduced into the furnace as the wagons arrived, the entire load being dumped immediately. The immediate dumping of the wagon was necessary owing to the absence of storage space and resulted in a very irregular application of garbage. It was, moreover, necessary to leave the charging hole of the furnace open during the entire time required for the emptying of a wagon. This period averaged 10 minutes, and it will be readily seen that during this time the furnace suffered an appreciable lowering in temperature. At the time of the introduction of the first loads into cells Nos. 1 and 2, the temperature of the cells was about 100 degrees F., and the fires were then started. The introduction of succeeding loads had the effect of lowering the temperature within the cells and thus retarding the progress of the burning of the garbage previously introduced.

Use of Fuel and Methods of Firing. Previous to the introduction of any garbage small fires were built in the fire boxes of each cell of the furnace, but were kept banked until the first garbage was introduced into the cell. These fires had but small effect on the temperature of the

furnace before starting the test, and the coal consumption was very small. Upon the introduction of the first garbage into cell No. 1 at 10:30 A. M., July 29th, the upper and lower fuel fires of that cell were started. The fires in cell No. 2 were not started until 2:00 P. M., July 29th, when a load of garbage was introduced into that cell. The fireman at the plant was allowed to follow his usual methods of firing, and the fuel was applied very improperly and in a manner conducive neither to fuel economy nor the production of high or even constant temperatures. The coal was added in amounts averaging 55 pounds to each fire at infrequent and very irregular intervals, which varied from 15 minutes to 2 hours, and averaged about 45 minutes. The handling of the fires was also faulty in that the fuel beds were maintained very uneven and covered only a portion of the grates. None of the fires were clinkered during this test. The proper firing of the upper fires in each cell is difficult to accomplish, owing to the fact that these fire boxes are 5 feet 4 inches above the floor. The upper fuel beds covered only the front portion of the grate bars, the rear portion being free of coals.

The fires in each cell were kept alive from the time of starting on July 29th, until 8:30 A. M., July 30th, except during an interval from 5:40 P. M., July 29th, to 5:30 A. M., July 30th, when they were banked.

The coal used for the test was run-of-mine, obtained from a bank mine a few miles south of Canton. The analyses of the coal and its ash produced by burning were as follows:

	Coal.	*Ash.*
Moisture	7.16%	9.90%
Combustible	82.14%	16.79%
Calorific value (B. T. U.)	10,983	1,903

Stoking. On July 29th the garbage was stoked infrequently, but toward the end of the test on the morning of July 30th, stoking was more frequent, permitting a rapid burning of the dried and easily combustible material. More frequent stoking in the earlier portion of the test would probably have assisted in the drying.

Temperatures. The results of the high temperature measurements indicate improper operation. The temperatures within the fire boxes varied from about 1000 to 2000 degrees F., and fluctuated greatly owing to the irregularity of firing. The irregularity of temperature was also shown in the readings taken within the garbage combustion chamber. The maximum temperature attained in cells Nos. 1 and 2 were 1065 and 1000 degrees, respectively, and the averages of all observations for cells Nos. 1 and 2 were 522 degrees and 553 degrees, respectively. The maximum temperatures occurred at the end of the test, when the garbage, having dried completely, was burning brightly. The flue temperatures at no time during the test became very high, but this is due to the low temperatures within the furnace and is not an indication of a large utiliza-

tion of heat. The flue temperatures were about equal to the average temperatures of the cell itself.

Draft. Duing the test no attempt was made to vary draft conditions by the handling of the dampers, and at all times the dampers were allowed to remain open as far as possible. This permitted an excessive loss of heat by way of the stack, especially in the latter portion of the firing.

Flue Gas Analyses. No samples of flue gas were taken during the early portion of the test, owing to the failure of the Orsat apparatus. Samples taken during the last few hours of the test when the garbage was dried and burning briskly indicated that at that time a fair degree of combustion was attained.

Odors. The odors within the plant and in the immediate vicinity were not objectionable at any time during the test. At various times during the test, odors could be noted at distances of 1000 feet or more from the plant. At all times except immediately following firing, when the smoke from the fuel obscured it, thin vapor issued from the stack.

Ashes from Garbage. The ashes remaining from the burning of the garbage were of a dark grayish brown color and contained small bits of unburned material, and had a slight unpleasant odor. The ashes from cell No. 1 weighed 603.5 pounds, representing 11.7 per cent. of the garbage placed within the cell. Those from cell No. 2 weighed 452.5 pounds or 12.6 per cent. of the garbage placed within the cell. A sample of the ashes was collected and the analysis was as follows:

Moisture	1.5%
Combustible	18.31%
Calorific value (B. T. U.)	341

Test of July 30, 1909.

In this test an attempt was made to study the furnace under special operating conditions. To this end it was arranged to have the garbage applied at regular intervals with the furnace at a high temperature and to maintain proper firing conditions. Cell No. 2 was alone used for this test. In preparation of the test the cell was thoroughly cleaned and allowed to cool to a temperature of about 200 degrees F. The two fires in the fuel furnace of cell No. 2 were started at 10:00 a. m., July 30th, and regular firing conditions were maintained until 3:30 p. m., July 30th, when the garbage was completely burned. The observations of this test are presented in table No. 88.

TABLE NO. 88.

OBSERVATIONS DURING CREMATORY TEST AT CANTON.

Cell No. 2. *July* 30, 1910.

Period.	Temp. Upper Fire.	Temp. Lower Fire.	Aver. Temp. of Furnace.	Flue Temp.	Draft.	Flue Gas Analyses. CO_2.	Flue Gas Analyses. O_2.	Flue Gas Analyses. CO.	Remarks.
10:05-10:15 A. M.	1,420	1,600	482	610	.29	2.0	17.8	0	Fires started at 10:00 A. M.
10:20-10:30 A. M.	1,540	2,040	542	.....	.....	.....	.....	.....	
10:30-10:45 A. M.	1,780	2,060	788	.....	.....	.....	.....	.....	
10:50-11:00 A. M.	1,900	1,950	1,000	.....	.....	.....	.....	.....	
11:00-11:15 A. M.	1,890	2,180	1,160	680	.35	3.0	17.0	0	Garbage introduced at 11:10 A. M.
11:20-11:30 A. M.	1,910	2,550	1,290	.....	.....	.....	.....	.....	Garbage introduced at 11:25 A. M.
11:35-11:45 A. M.	.....	.....	640	775	.39	.....	.....	.....	
12:35-12:45 P. M.	1,790	2,310	1,150	800	.37	4.5	14.7	0	Garbage introduced at 12:20 P. M.
12:50- 1:00 P. M.	1,940	2,410	795	.....	.....	.....	.....	.....	Garbage introduced at 12:50 P. M.
1:05- 1:15 P. M.	2,020	2,170	1,050	950+	.39	4.5	15.5	0	Garbage introduced at 1:15 P. M.
1:20- 1:30 P. M.	2,450	2,700	1,490	1,220*	.....	7.6	11.6	0	Garbage introduced at 1:30 P. M.
1:35- 1:45 P. M.	2,050	1,750	1,395	950+	.42	.....	.....	.....	
1:50- 2:00 P. M.	2,150	2,470	1,438	.....	.....	5.5	14.7	0	
2:05- 2:15 P. M.	2,440	2,250	1,595	800+	.40	.....	.....	.....	
2:20- 2:30 P. M.	2,000	2,250	1,518	1,100*	.....	4.2	15.2	0	
2:30- 2:45 P. M.	2,010	2,440	1,410	800+	.40	.....	.....	.....	
2:50- 3:00 P. M.	2,010	2,690	1,355	.....	.....	3.4	17.2	0	
3:05- 3:15 P. M.	1,580	2,170	1,252	690	.36	.....	.....	.....	
3:20- 3:30 P. M.	1,720	2,400	1,100	.....	.....	2.4	18.4	0	
3:35- 3:45 P. M.	940	1,620	990	.....	.....	.....	.....	.....	Fires drawn at 3:30 P. M.
Average	1,870	2,210	1,122	852	.37	4.1	15.8	0	

* Temperature in stench consuming furnace.

Refuse Destroyed. During this test 5880 pounds of garbage were destroyed. The garbage burned during this test was almost identical in appearance with that of the previous day, consisting principally of wet vegetable, fruit and melon wastes. Its weight averaged 1205 pounds per cubic yard. A composite sample of the material gave the following analytical results:

Moisture	77.3%
Ash	3.10%
Combustible	19.60%
Ether extract	4.75%
Phosphoric acid (P_2O_5)	0.36%
Kjeldahl nitrogen	0.60%
Potash (K_2O)	0.28%
Calorific value	1,971

All of the garbage was stored as it arrived and was introduced into the cell after high temperatures had been reached in six approximately equal portions between 11:10 A. M. and 1:30 P. M. The method of application of the garbage aside from producing uniform conditions, shortened greatly the time necessary to keep the charging holes open. It required no longer than one minute to introduce each of the six charges, and the reduction of temperature within the furnace was slight. The greater portion of the garbage was placed in that part of the cell near the fire boxes, but a small portion was also placed at the other end of the furnace and readily burned at this point.

Fuel Used and Method of Firing. The coal used for this test was of the same quality as that used on the preceding day. The application of fuel was maintained as regular as feasible. At intervals of 8 to 10 minutes about 30 pounds of coal were added to each fire. The fuel beds were kept level, covering the grate bars uniformly to a depth of 6 to 8 inches. The fires were started at 10:00 A. M. and the furnace heated to a temperature of 1150 degrees at 11:10 A. M., when the first charge of garbage was introduced. For this purpose 678 pounds of coal were used. The total coal used during the test was 2071 pounds or .335 pound per pound of garbage. Deducting that required for heating the furnace, the coal consumption was .225 pound per pound of garbage, which more nearly represents the consumption if continuous operation were employed.

Stoking. During the 4½ hours between the introduction of the first charge of garbage and the end of the test the material was frequently stoked and stirred to facilitate drying and combustion. This frequent stoking probably tended to cool the furnace somewhat, but assisted greatly in the rapid burning of the garbage.

Temperatures. The temperature measurements within the cell indicated that a much more regular and higher temperature was main-

tained than during the first test. At all times during the destruction of the garbage the cell had a temperature averaging 1127 degrees, and varying from 1595 degrees down to 640 degrees, the latter temperature occurring at but one time and immediately following the introduction of a large charge of garbage. The temperatures throughout the test were maintained very regular by the conditions of firing and fluctuations were not numerous. It was impossible, however, to keep the flue temperature low, and toward the end of the test it reached a temperature of 1000 degrees or more. This, of course, represents a large loss of heat, but is unavoidable with the present design of furnace.

Draft. The flue draft was controlled somewhat by the handling of the furnace damper. During the early portion of the firing and after the introduction of each charge of garbage, the damper was opened wide to permit of free passage of gases to the stack. At other times, however, the damper was partially closed. The average of all draft readings was .37 inch, the maximum being .42 inch, when the furnace was at high temperature.

Flue Gas Analyses. The analyses of samples of flue gas taken during the test indicate a fair degree of combustion and show a very marked improvement over the results obtained on July 29, 1909. The average of all analyses is as follows:

CO_2	4.1%
O_2	15.8%
CO	0%
N.	80.1%

Odors. Except at the times immediately following the dumping of a charge of garbage, none of the characteristic light colored vapor was noted issuing from the stack. The gases from the stack were invisible during the greater portion of the test, and were colored only following the introduction of garbage into the furnace or coal on to the fires. The storage of garbage caused some odor at the plant owing to the vaporization of water leaking from the garbage on to the top of the furnace. At distances of 1000 feet from the plant in the direction of the wind, however, no odors were detected at any time during the test.

Ashes from Garbage. The ashes from the garbage were of a dark gray color and contained no visible unburned material. They possessed no odor. The total weight of the ashes was 478.5 pounds, representing 8.1 per cent. of the garbage placed within the cell. A sample gave the following analysis:

Moisture	0.25%
Combustible	13.49%
Calorific value	0

Test of February 2-3, 1910.

This test was conducted under the ordinary operating conditions, the furnace being cold and partially filled with garbage at the beginning of the test. On February 1st, all of the garbage arriving at the plant was placed in cell No. 2, and the test proper was not started until the morning of February 2nd. The garbage of February 2nd was introduced into the cell as it arrived. The conditions of this test differed from those of July 29, 1909, in that only one cell was used and better methods of firing and general operation followed. The observations of this test are given in table No. 89.

TABLE NO. 89.

OBSERVATIONS DURING CREMATORY TEST AT CANTON, FEBRUARY 2-3, 1910.

Period.	Av. Temp. of Furnace.	Flue Temp.	Draft.	Garbage Introduced. Time	Garbage Introduced. Weight (lbs.)	Remarks.
Feb. 2nd.						
10:10–10:25A	516	.....	.29	10:50A	1,100	Fires started 8:40 A. M.
11:05–11:25A	895	555	.33	11:10A	680	
11:50–11:55A	345	435	.36	11:30A	1,220	
1:00– 1:10P	933	720	.41	.....	.....	
2:15– 2:30P	1,125	.....	.....	1:50P	705	
4:05P	1,040	735	.46	3:45P	765	
4:45P	1,335	800+	.45	4:35P	645	
5:00– 5:20P	1,310	.....	.....	5:00P	515	Fires banked 5:30 P. M.
Feb. 3rd.						
8:40– 8:45A	200	240	.21	.....	.....	Fires started 8:45 A. M.
9:20–10:00A	926	360	.38	.....	.....	
10:25–11:00A	1,298	700	.43	.....	.....	Temp. upper fire 1860°; lower fire 2130°.
11:35A–12:45P ...	913	600	.47	.....	.....	
1:00– 1:15P	1,095	530	.44	.....	.....	
1:40– 2:00P	1,218	.....	.....	.....	.....	
2:15P	1,330	560	.48	.....	.....	
2:25– 2:35P	1,073	.....	.....	.....	.....	Discontinued firing 3:30 P. M.
Average	972	567	.39	.....	.....	

Refuse Destroyed. During this test 11,620 pounds of garbage were introduced into the cell. All of the garbage delivered on February 1st, amounting to 5,990 pounds, was placed within the cell immediately upon its arrival. Following the starting of the fires at 8:40 A. M., February 2nd, the following garbage was introduced:

Time.	*Weight Pounds.*
10:50 A. M.	1,100
11:10 A. M.	680
11:30 A. M.	1,220
1:50 P. M.	705
3:45 P. M.	765
4:30 P. M.	350
4:35 P M.	295
5:00 P. M.	515
Total	5,630

The garbage was principally kitchen refuse, consisting largely of vegetable and fruit peelings. About one-half of the garbage was frozen. The weight of the garbage averaged 1,024 pounds per cubic yard. Two composite samples, representing the garbage received on February 1st and 2nd, respectively, were collected and the averages of the analytical results follow:

Moisture	72.9%
Ash	2.53%
Combustible	24.52%
Ether extract	5.26
Phosphoric acid (P_2O_5)	0.20%
Kjeldahl nitrogen	0.63%
Potash (K_2O)	0.26%
Calorific value (B. T. U.)	2,471

The garbage was dumped immediately upon the arrival of the wagons, the entire quantity being placed in that portion of the furnace near the fire boxes. The charging holes were open on an average of eight minutes for each load dumped.

Use of Fuel and Methods of Firing. With the furnace cold and containing 5,990 pounds of garbage, the fires were started at 8:40 A. M., February 2nd, and pushed as rapidly as possible to raise the temperature of the furnace. A proper method of firing was followed and the fires were given attention at intervals averaging 20 minutes, when an average of 50 pounds of fuel was added to each fire. At 5:30 P. M., February 2nd, the fires were banked for the night, being rekindled on the morning of February 3rd at 8:45. Firing was continued until 2:00 P. M., February 3rd, and the garbage had burned out completely at 3:30 P. M. The ashes were removed and weighed on the following day. The coal used was obtained from a bank mine a few miles south of Canton. The analyses of the coal and of the ashes from the grates are as follows:

	Coal.	*Ash.*
Moisture	7.90%	.....
Combustible	84.18%	20.64%
Calorific value (B. T. U.)	11,748	1,924

Stoking. No stoking was done during the early portion of the test while the furnace was heating, but after burning temperatures were reached the garbage was stoked at intervals of 20 to 25 minutes. Each stoking required a period of four minutes, and the furnace was open for stoking purposes a total of 90 minutes or 10.7 per cent. of the length of the test.

Temperatures. During the first three hours of the test the temperatures within the cell were not great enough to bring about the burning of the garbage and only a drying action took place. After this period had passed, however, fairly constant and high temperatures were maintained.

The results of the high temperature measurements show that the average temperature maintained within the combustion chamber during the test was 972 degrees F. The temperature fluctuated from 350 degrees to 1,335 degrees F., these fluctuations being brought about by the discharge of garbage in to the cell. The firing conditions could not be regulated to avoid these fluctuations. The flue temperatures reached 1,000 degrees toward the close of the first day's firing, but at all other times the measurements indicated a somewhat lower temperature.

Draft. The strength of the draft was regulated as far as possible by the manipulation of the damper. It was left open during the early stages of firing and immediately following the dumping of garbage, but when the cell was at high temperature the damper was partially closed. The draft measurements varied from about 0.20 inch when the furnace was at low temperature, to 0.49 inch in the latter portion of the test when high temperatures were attained.

Odors. The odors within and about the plant were not noticeably objectionable during the test. At a point about 1,000 feet from the plant, however, a very distinct odor of the gases from the stack was noticed at 10:20 A. M., February 2nd, before high temperatures had been attained within the cell. At 3:00 P. M., February 2nd, the wind conditions remaining the same, no odor was noticed at the same point of observation. At this time the furnace was at a high temperature. The gases leaving the stack were observed at various times when not obscured by the coal smoke. At all times except during the latter portion of the test when high temperatures were reached, the characteristic light vapor was noticed.

Ashes from Garbage. The ashes from the garbage were of a dark gray color, very finely divided, and contained no visible unburned material. No odor was apparent. The total weight of ashes was 472 pounds, representing 4.1 per cent. of the weight of garbage introduced into the furnace. A sample of the ashes was collected and its analysis was as follows:

Moisture	0.0%
Combustible	8.07%
Calorific value	0

MANSFIELD.

A test on the Mansfield garbage crematory was conducted November 18 and 19, 1909. This test was made with the idea of observing the conditions of operation brought about by the methods usually employed at the plant. In general, the test consisted in the destruction of garbage arriving at the plant on three days, November 17, 18 and 19, 1911. The test was begun on the morning of November 18th and concluded on the evening of November 19th. Throughout the test, except during an interval of 16 hours on the night of November 18th, the usual observations were made to determine the action of the furnace. A tabulation of the principal observations is given in table No. 90, and the items pertaining to the conditions of the test and results are given in table No. 91.

On November 17th, the day previous to the beginning of the test, the furnace was cleaned and allowed to cool to about air temperature. On November 18th, immediately before the beginning of the test, 3,475 pounds of garbage which had been received the previous day was placed within the cell and at 8:40 A. M. the fires were started in the fuel furnace. The firing was continued regularly thereafter until 4:30 P. M., November 18th, when the fires were allowed to die down and were banked until the following morning at 9:00 A. M., when they were rekindled. Firing was discontinued at 3:10 P. M. and the garbage was completely burned at 5:30 P. M., November 19th, and after the furnace had cooled sufficiently the ashes were removed and weighed.

TABLE NO. 90.

OBSERVATIONS DURING CREMATORY TEST AT MANSFIELD, NOVEMBER 18-19, 1909.

Period.	Temp. Fire.	Aver. Temp. of Furnace.	Flue Temp.	Draft.	Flue Gas Analyses.			Garbage Introduced.		Remarks.
					CO_2.	O_2.	CO.	Time.	Weight (lbs.)	
Nov. 18th.										
9:15- 9:20 A.	.....	506	.....	.....	.....	.....	.....	.....	.....	
9:35-10:10 A.	1,980	744	510	.30	9.2	9.2	0	.....	.....	Fire started 8:40 A. M.
10:25-10:35 A.	.....	1,060	.....	.....	9.0	9.8	0.2	9:30 A.	2,110	
10:40-10:55 A.	.....	1,060	570	.33	8.6	11.0	0.1	10:00 A.	35	
11:10-11:30 A.	2,280	1,210	640	.34	10.5	8.9	0.2	.....	.....	
12:20-12:45 P.	.....	1,120	770	.31	7.4	12.0	0	.....	.....	
1:40- 2:00 P.	2,420	1,075	620	.33	7.9	9.7	1.8	.....	.....	
2:20- 2:45 P.	.....	1,226	800	.34	7.8	11.6	0.4	1:30 P.	2,220	
3:00- 3:30 P.	.....	1,112	800*	.34	7.2	12.2	0	.....	.....	
4:40- 4:45 P.	.....	1,052	930*	.36	9.6	8.8	1.0	.....	.....	
5:00- 5:10 P.	.....	1,430	.....	.....	9.3	9.5	0.8	.....	.....	Fire banked at 4:30 P. M.
								8:30 A.	1,570	
								8.45 A.	548	
Nov. 19th.								9:30 A.	1,575	Fire started 9:00 A. M.
9:05- 9:15 A.	.....	150	.....	.....	.....	.....	.....	.....	.....	
10:00-10:05 A.	.....	550	200	.28	1.3	18.7	0	.....	.....	
10:30-10:45 A.	.....	870	550	.30	8.6	9.2	1.9	.....	.....	
11:05-11:10 A.	.....	930	560	.30	9.9	8.0	2.0	.....	.....	
11:35-11:45 A.	2,340	1,020	650	.28	8.1	9.5	1.6	.....	.....	
12:55- 1:10 P.	.....	1,045	790	.30	9.4	8.8	0.8	.....	.....	
1:35- 1:50 P.	.....	1,245	790	.32	8.0	9.9	1.1	.....	.....	
2:00- 2:20 P.	2,080	1,250	.....	.32	8.1	11.7	0	.....	.....	
2:45- 2:55 P.	.....	1,277	750	.30	10.8	7.7	1.2	.....	.....	
3:40- 3:45 P.	.....	1,095	800	.31	8.9	10.9	0	.....	.....	Firing discontinued 3:10 P. M.
4:00- 4:20 P.	1,930	1,022	.....	.....	6.1	14.3	0	.....	.....	
Average	2,172	1,002	670	.32	8.3	10.7	0.65	.....	.....	

* Temperature in furnace near flue.

TABLE NO. 91.

DATA ON CREMATORY TEST AT MANSFIELD, NOV. 18-19, 1909.

Duration of test (hours)	31.6
Quantity garbage destroyed (lbs.)	11,473
Time required to burn garbage (hours)	31.6
Number hours during which coal was used	14
Quantity garbage destroyed per hour (lbs.)	363
Quantity of garbage destroyed per hour per square foot grate area	4.32
Quantity of garbage destroyed per hour during use of coal	819
Quantity of garbage destroyed per hour during use of coal per square foot of grate area	9.75
Average percentage moisture in garbage	77.6
Weight of ashes remaining (lbs.)	583.5
Per cent. ashes of total weight of garbage	5.1
Quantity of coal used (lbs.)	2,072
Coal used per hour of firing (lbs.)	148
Coal used per hour per square foot grate area (lbs.)	11.1
Coal used per hour per ton garbage (lbs.)	.362
Heating value of coal (B. T. U.)	12,617
Heat units in coal used per pound of garbage (B. T. U.)	2,284
Fuel cost per ton of garbage destroyed	$0.34
Average temperature combustion chamber (Degrees F.)	1,002
Maximum temperature combustion chamber (Degrees F.)	1,430
Average flue temperature (Degrees F.)	670
Average furnace room temperature (Degrees F.)	77

Refuse Destroyed. During the test, 11,473 pounds of garbage were burned. At the time the test was started the furnace contained 3,475 pounds, and during the progress of the test garbage was introduced as follows:

	Time.	*Weight of Garbage.*
Nov. 18.	9:30 A.	2,110
	10:00 A.	35
	1:30 P.	2,220
Nov. 19.	8:30 A.	1,570
	8:45 A.	548
	9:30 A.	1,515

The garbage received for burning was principally that collected by the Sanitary Garbage Company in 10-gallon cans, and was therefore of household origin. It was wet and dirty in appearance and contained a rather large quantity of rubbish, and its principal constituents were vegetable wastes. A composite sample of the garbage gave the following analysis:

Constituent.	*Percentage.*
Moisture	77.65
Ash	3.15
Combustible	19.20
Ether extract	3.42
Phosphoric acid (P_2O_5)	0.17
Kjeldahl nitrogen	0.92
Potash (K_2O)	0.30
Calorific value (B. T. U.)	1,832

The garbage placed in the cell after the test had been started was dumped immediately upon the arrival of the wagons. This resulted in a very irregular introduction of the garbage and thus interfered with the regularity of the action of the furnace. The necessity of leaving the furnace open during the dumping of a load also introduces a factor affecting the operation of the furnace. All the garbage was placed in that portion of the cell near the fuel fire for the purpose of keeping that section of the grate bars well covered to prevent short-circuiting.

Use of Fuel and Methods of Firing. During the test, the usual methods of firing ordinarily employed at the plant were used. The fire at all times was kept in good condition, being clinkered frequently, and the fuel bed was maintained level, covering the grate bars with a thickness of about six inches. The coal was added in quantities of about 80 pounds at intervals averaging 37 minutes. This method of firing produced a high temperature within the fire box, and the conditions at this point were quite constant. The fire was maintained at a high temperature at all times excepting an interval of 16½ hours on the night of November 18th, when the fires were banked. The coal used was Hocking run-of-mine, costing $1.90 per ton, delivered at the plant. Its analysis was as follows:

Combustible	95.58 per cent.
Calorific value, B. T. U.	12,617

The proper care for the fire is shown by an analysis of the ash, which contains 16.22 per cent. combustible, a low figure for the coal used.

The total weight of the coal used during the test was 2,072 pounds, which is equivalent to 0.181 pound of coal per pound of garbage destroyed, or 362 pounds per ton of garbage.

Stoking. During the test somewhat greater attention was given to the stoking of the garbage than is the usual custom at the plant. Ordinarily, only a small amount of stoking is required, owing to the fact that the garbage is at all times surrounded by a flame from the fuel. Observations during the test indicated that the garbage was stoked at intervals averaging 40 minutes.

Temperatures. The temperature over the fuel fire at all times was maintained in excess of 2,000 degrees. This temperature was main-

tained regularly and fluctuations were infrequent. Within the garbage cell the average of all temperatures was 1016 degrees, the maximum recorded being 1403 degrees. The average temperature was somewhat lower than that required for complete combustion without odor, and does not represent the temperature which was maintained during the greater portion of the test. The figure given is somewhat lower than the true average, owing to the low temperatures observed during the early portion of the firing, and included in the average. Measurements within the stack flue indicate that a considerable quantity of heat, especially during the periods of high temperature within the furnace, is carried out by the products of combustion.

Draft. The draft readings made at intervals during the test show a great regularity, brought about by the equalizing effect of the boiler fires which are served jointly with the garbage furnace by one stack. No damper is provided in the flue by means of which the draft may be regulated, and its absence permits an excessive heat loss with the furnace at high fire.

Flue Gas Analyses. Samples of the gases from the furnace were taken at intervals during the test and analyzed at the plant. In general, the analyses indicated a very satisfactory degree of combustion and give results which are better than those obtained from other incinerators in the state. The average of all analyses shows the following percentages: CO_2, 8.2 per cent.; O_2, 10.6 per cent.; CO, 0.65 per cent.

Odors. During the progress of the test, no opportunity was had for noting odors in the vicinity of the plant. On the day previous, however, an inspection at a distance of 1000 feet from the plant failed to reveal the presence of objectionable odors arising from the burning of garbage.

Ashes from Garbage. The ash produced by the burning of the garbage was of a dark grayish color, very finely divided, and contained no bits of unburned material. Its appearance, however, indicated a quantity of unburned carbonaceous matter. No odor was apparent. The total weight of the ashes was 583.5 pounds, representing 5.1 per cent. of the garbage placed within the cell. A sample of the ash showed the presence of 16.78 per cent. combustible matter, and a calorimetric determination showed 1136 B. T. U.

MARION.

One test was conducted at the crematory at Marion on October 28 and 29, 1909. The test consisted in observing the conditions attending the cremation of two days' collection of garbage and other refuse received at the plant. The usual methods of operation employed by the operator were followed, and, as far as could be determined, the conditions attending the test, including the quantity and character of the

refuse received, the handling of the fires, etc., were typical of the average conditions. All garbage and refuse delivered at the plant during the two days of the test were burned. The test was begun at 10:40 A. M., October 28th, and continued until 11:40 P. M., October 29th. During this time, excepting an interval of 14.5 hours, from 5:00 P. M., October 28th, until 7:30 A. M., October 29th, the furnace was in operation and observations were made of the test. The total length of the test was therefore 37 hours, of which time the furnace was in operation 22.5 hours. At the end of the test, when it was observed that all of the material had been converted into an ash, the furnace was allowed to cool and the ashes were removed, weighed and sampled. Tables Nos. 92 and 93, respectively, give the observations and data relating to the conditions of the test and results obtained.

TABLE NO. 92.

OBSERVATIONS DURING CREMATORY TEST AT MARION, OCTOBER 28-29, 1909.

Period.	Average Temp. of Cell.	Flue Temp.	Flue Draft.	Flue Gas Analyses.				Refuse Introduced.			Remarks.
				CO_2.	O_2.	CO.	N.	Time.	Weight	Class	
Oct. 28.											
11:06–11:15 A.	342	150	0.19	0.8	19.7	0	79.5	10:40 A	1,825	Garbage.	Fire started in east burner 10:40 A. M.
11:35-11:40 A.	383	250	0.24	0.8	19.5	0	79.7	.....	.....		
12:40-12:55 P.	705	220	0.28	1.5	18.7	0	79.8	.....	.....		
1:05- 1:15 P.	717	240	0.28	1.2	19.1	0	79.7	.....	.....		
1:40- 1:55 P.	838	.....	0.25	1.1	19.2	0	79.7	.....	.....		
2:20- 2:25 P.	833	300	0.28	1.6	18.6	0	79.8	.....	.....		East burner off, west burner on, 2:30 P. M.
3:00- 3.10 P.	940	.....	.....	.....	.....	.....	.....	3:00 P	1,325	Mixed garbage and rubbish.	
4:00- 4:20 P.	838	300	0.41	1.0	19.2	0	79.8	3:30 P	2,365	Night soil.	West burner off, east burner on, 4:00 P. M.
4:10- 4.45 P.	737	.....	0.30	1.0	19.2	0	79.8	.....	.....		
5:00- 5:50 P.	813	.....	0.27	.....	.....	.....	.....	.....	.....		

TABLE NO. 92—Continued.

OBSERVATIONS DURING CREMATORY TEST AT MARION, OCTOBER 28-29, 1909.

Period.	Average Temp. of Cell.	Flue Temp.	Flue Draft.	Flue Gas Analyses.				Refuse Introduced.			Remarks.
				CO_2.	O_2.	CO.	N.	Time.	Weight.	Class.	
Oct. 29.											
8:30- 8:40 A.	566	360	0.19	1.0	18.8	0	80.2	7.40 A	365	Garbage.	
9:10- 9:35 A.	677	230	0.25	1.0	18.2	0	80.8	8:20 A	190	Garbage.	
10:35-10.40 A.	785	240	0.29	1.4	19.2	0	79.4	8:20 A	160	Mixed refuse.	
11.30-11:40 A.	1,037	340	0.30	1.1	18.6	0	80.3	.....	.....		
								9:45 A	1,475	Night soil.	
1:00- 1:25 P..	990	310	0.27	1.2	18.5	0	80.3	9:50 A	875	Night soil.	
								11:00 A	1,575	Garbage.	
1:50- 2:05 P..	925	320	0.27	1.1	18.6	0	80.3	11.40 A	2,380	Night soil.	
2.45- 3:05 P..	938	270	0.27	1.2	18.5	0	80.3	.....	.....		
4:15- 4:50 P..	965	240	0.28	1.2	18.4	0	80.4	.....	.....		
6:35- 6:45 P..	665	210	0.30	.....	.....	.....	.....	.....	.....		East burner off, west burner on, 5:30 P. M.
7:15- 7:20 P..	787	430	0.37	1.3	18.3	0	80.4	.....	.....		
8:20- 8:35 P..	902	590	0.35	1.2	18.5	0	80.3	.....	.....		
9:55-10:15 P..	1,040	380	0.38	1.5	18.0	0	80.5	.....	.....		
11:15-11:30 P..	1,140	340	.....	1.2	18.2	0	80.6	.....	.....		
								.....	.....		West burner off, 11:40 P. M.
Average ..	803	290	0.29	1.2	18.7	0	80.1	.....	.....		

TABLE NO. 93.

DATA ON CREMATORY TEST AT MARION, OCT. 28-29, 1909.

Duration of test (hours)	37
Quantity of garbage destroyed (lbs.)	3,955
Quantity of mixed garbage and rubbish destroyed (lbs.)	1,485
Quantity of night soil destroyed (lbs.)	7,095
Total refuse destroyed (lbs.)	12,535
Time required to burn all refuse (hours)	37
Number of hours during which fuel was used	22.5
Quantity of refuse destroyed per hour per square foot grate area	2.48
Quantity of refuse destroyed per hour during use of fuel	557
Quantity of refuse destroyed per hour during use of fuel per square foot grate area	4.07
Average percentage moisture in garbage	78.5
Weight of ashes from refuse (lbs.)	933.5
Percentage of total refuse	7.45
Gas used (cubic feet)	38,270
Average gas per hour of firing (cubic feet)	1,701
Gas per pound refuse destroyed (cubic feet)	3.05
Heating value of fuel (B. T. U. per cubic foot) (estimated)	1,100
B. T. U. in gas per pound refuse destroyed	3,355
Fuel cost per ton refuse destroyed	$0.915
Average temperature in combustion chamber, degrees F.	803
Maximum temperature in combustion chamber, degrees F.	1,140
Average flue temperature at base of stack, degrees F.	290
Average furnace room temperature, degrees F.	57

Refuse Destroyed. All refuse was placed within the cell immediately upon its arrival at the plant. In general, the refuse received during the test was made up of three classes, namely, garbage, which consisted largely of vegetable wastes; mixed garbage and rubbish, obtained largely from commission houses, groceries, etc.; and night soil. The following quantities of these wastes were destroyed:

Garbage	3,955 pounds.
Mixed garbage and rubbish	1,485 pounds.
Night soil	7,095 pounds.

This material was introduced into the furnace according to the following schedule, which corresponds to the time of arrival of the collection wagons:

Time.	Class of Refuse.	Weight (lbs.)
Oct. 28, 10:40 A.....	Garbage	1,825
Oct. 28, 3:00 P.....	Mixed garbage and rubbish.....	1,325
Oct. 28, 3:30 P.....	Night soil	2,365
Oct. 29, 7:40 A.....	Garbage	365
Oct. 29, 8:20 A.....	Garbage	190
Oct. 29, 8:20 A.....	Mixed refuse	160
Oct. 29, 9:45 A.....	Night soil	1,475
Oct. 29, 9:50 A.....	Night soil	875
Oct. 29, 11:00 A.....	Garbage	1,575
Oct. 29, 11:40 A.....	Night soil	2,380

The garbage received was entirely of household origin and consisted almost entirely of vegetable wastes. Its moisture content was very high, and the loads contained a large quantity of free water. Two composite samples were collected on October 28 and 29, respectively, and their analyses gave the following averages:

Moisture	78.5 per cent.
Ash	2.95 per cent.
Combustible	18.60 per cent.
Ether extract	4.51 per cent.
Phosphoric acid, P_2O_5.....	0.18 per cent.
Kjeldahl nitrogen	0.57 per cent.
Potash, K_2O	0.23 per cent.
Calorific value, B. T. U.....	1,925

The mixed garbage and rubbish was collected principally from commission and jobbing houses, and although it contained a large percentage of combustible material, it was, nevertheless, rather wet and of itself not readily combustible.

In dumping the garbage, this class of material was placed upon that portion of the evaporating floor near the fire boxes of the cell, where it could be brought under the direct action of the flames. The night soil was placed upon the evaporating floor about mid-way between the fire boxes, and by a slow process was dried and consumed. The last refuse was placed within the cell twelve hours before the completion of the test.

The opening of the furnace for the introduction of refuse caused some lowering of temperature within the cell, and this was especially true when a load of garbage was dumped. The emptying of the thirty cans contained in such a load required that the furnace be kept open about fifteen minutes.

Use of Fuel. The consumption of gas during the test was maintained fairly constant, the valve being regulated to produce a good mixture of gas and air for proper combustion. Fluctuations in the gas

pressure, however, made an accurate regulation impossible, and a variation in the amount of gas consumed per hour resulted. The gas burner in the easterly fire box was used during the greater portion of the test, but the burner in the westerly fire box was employed from 2:30 p. m. to 4:00 p. m., October 28, and from 5:30 p. m. to 11:40 p. m., October 29. During these periods the east burner was not used. It was necessary to change the fires in this manner in order to accomplish the destruction of that portion of the refuse upon the evaporating floor near the westerly fire box farthest removed from the other fire. The total consumption of gas during the test was 38,270 cubic feet, which represents a fuel cost of $0.915 per ton of refuse destroyed, and a use of 3355 B. T. U. per pound of refuse destroyed. These high values are accounted for largely by the character of the material burned.

Stoking. During the early portion of the test and until 1:30 p. m., October 29, stoking was infrequent. After this time, however, the refuse was stoked at intervals averaging 28 minutes until it was entirely destroyed. When the refuse is burning, stoking becomes necessary, as no draft can be carried through the material and its combustion must be brought about by heat and air supplied from above. If the ash is allowed to remain covering the unburned material, it forms a protecting shield which prevents further combustion.

The regular firing conditions made possible by the use of gas, produced a regularity of the temperature conditions within the furnace. In general, it was noted that the temperature increased gradually with the progress of firing, but other variations tended to create fluctuations in the temperature, which were made apparent by the measurements. The introduction of large quantities of refuse produced marked decreases in the temperature of the cell. The reversing of the draft within the furnace also lowered the temperature of the cell appreciably.

The measurements in general show that insufficiently high temperatures were reached. The average of all readings taken was 810 degrees, and the maximum cell temperature was 1140 degrees, this point being reached during the last half hour of the test. The flue temperatures were low, averaging 290 degrees. These temperatures are lower than should be expected, as they were taken at the base of the stack only a few feet from the furnace itself. The flue temperatures should be more nearly comparable with the furnace temperatures, and the fact that they are not indicates a large leakage of cold air into the flue.

Draft. The strength of the flue draft was largely dependent upon the temperature of the furnace, but the fluctuations were kept within narrow limits by the handling of the dampers placed in the stack flue. The average draft reading was 0.29 inch, the maximum being 0.41 inch.

Flue Gas Analyses. At frequent intervals during the test, samples of the flue gas were taken from the stack. Twenty samples in all were analyzed and very little fluctuation in their composition was noted. The

average of all analyses was as follows: CO_2, 1.2 per cent.; O_2, 18.7 per cent.; CO, 0 per cent. The analyses show that the flue gas at all times contains a large percentage of air, and the products of combustion formed but a small part of the total. This air probably enters through poorly fitted doors opening into the stack flue.

Ashes from Furnace. The ash produced by the combustion of the garbage was of a grayish brown color and was apparently well burned. It possessed no offensive odor. The ash from the night soil was of a light grayish color, and consisted of an impalpable powder without odor. The total weight of the ashes removed from the furnace was 933.5 pounds, representing 7.45 per cent. of the total refuse destroyed. Samples of the ashes were collected and gave the following analyses:

	Garbage Ash.	*Night Soil Ash.*
Combustible	12.24 per cent.	1.22 per cent.
Non-combustible	87.76 per cent.	98.78 per cent.
Calorific value B. T. U.	468.	none

STEUBENVILLE.

Furnace tests were conducted at the garbage crematory at Steubenville on September 23 and 24, 1909, during which the independent operation of the cells was studied. In the first test an attempt was made to operate the plant with a continuous draft through both cells and to study the results thus accomplished, but owing to the failure to secure sufficient draft for this purpose it was necessary to abandon the attempt and operate with a direct draft to the stack. The ordinary operation of the plant was therefore employed during each test. The conditions of firing, stoking, draft, etc., were maintained according to the usual custom of the operator. One day's collection of garbage and rubbish was destroyed during each test and the usual observance recorded. In table No. 94 are presented the data of principal interest regarding the tests.

TABLE NO. 94.

DATA ON CREMATORY TESTS AT STEUBENVILLE.

	Sept. 23, 1909.	Sept. 24, 1909.
Duration of test (hours)	6.33	7.0
Cells used for test	No. 1	No. 2
Quantity of garbage destroyed (lbs.)	7,830	6,400
Quantity of rubbish destroyed (lbs.)	1,775	750
Total quantity of refuse destroyed (lbs.)	9,605	7,150
Time required to burn refuse (hours)	6.33	7.0
Number of hours during which coal was used	6.33	6.0
Quantity of garbage destroyed per hour (lbs.)	1,237	914
Quantity of garbage destroyed per hour per square foot grate area (lbs.)	12.95	9.57
Quantity of garbage destroyed per hour during use of coal (lbs.)	1,237	1,067
Quantity of garbage destroyed per hour during use of coal per square foot grate area	12.95	11.77
Average percentage moisture in garbage	75.5	76.6
Weight of ashes remaining (lbs.)	888*	726*
Per cent. ashes of total weight of refuse	9.2	10.2
Quantity of fuel used (lbs.) coal	2,447	2,473
Quantity of fuel used (lbs.) wood	450	385
Equivalent coal (lbs.)	2,637	2,636
Equivalent coal used per hour firing (lbs.)	416	439
Equivalent coal used per hour per square foot grate area (lbs.)	11.6	12.2
Equivalent coal used per ton of garbage	674	824
Equivalent coal used per ton of total refuse	548	736
Heating value of coal (B. T. U.)	12,625.	12,625.
Heating value of wood (B. T. U.) (estimated)	5,400	5,400
Heat units in equivalent coal used per pound of garbage	4,254	5,201
Heat units in equivalent coal used per pound of total refuse	3,459	4,646
Fuel cost per ton refuse destroyed	$0.51	$0.69
Average temperature combustion chamber, degrees F.	689	742
Maximum temperature combustion chamber, degrees F.	895	850

*Ashes from garbage and fuel weighed together. Weight of garbage ashes estimated by deducting weight of ashes from fuel assumed to be 12 per cent. of total weight of fuel.

TEST OF SEPTEMBER 23, 1909.

On the day previous to this test, one of the cells (cell No. 1) was cleaned thoroughly and allowed to cool. Before the fires were started on September 23, 7,830 pounds of garbage were contained within the cell. The fires were started at 9:40 A. M. and continued in use until 4:00 P. M., when it was observed that the garbage was almost completely burned. During the first hour of this test an attempt was made to conduct the draft through the idle cell of the furnace, but this proved a failure and it became necessary to operate the cell with a direct draft. After the garbage had burned out the cell was permitted to cool until the following morning, when the ashes were removed and weighed. Table No. 95 contains observations made during the test.

TABLE NO. 95.

OBSERVATIONS DURING CREMATORY TEST AT STEUBENVILLE, SEPTEMBER 23, 1909.

Period.	Average Temp. Fuel Fires.	Aver. Temp. of Furnace.	Draft.	Flue Gas Analyses.				Rubbish Introduced.		Remarks.
				CO_2	CO	O_2	N.	Time.	Weight (lbs.)	
11:20-11:30 A.....	1,365	570	.63	2.5	0.1	17.9	79.5	10:10 A.	200	Fires started 9:40 A. M.
12:45 P.....	.....	845	.....	.....	.....	.....	.....	.....	.....	Furnace contained 7,830 pounds garbage
1:25- 1:40 P.....	.....	571	.64	1.7	0.0	18.6	79.7	.....	.....	and 300 pounds rubbish.
1:45- 1:55 P.....	.....	874	.63	2.4	0.1	18.1	79.4	.....	.....	
2:15- 2:40 P.....	.....	650	.64	1.1	0.0	20.1	78.8	2:20 P.	400	
								2:40 P.	400	
2:45- 3:00 P.....	.....	437	.74	.....	.....	.....	.....	2:50 P.	400	
3:05- 3:20 P.....	.....	895	.57	1.2	0.0	19.7	79.1	.....	.....	
3:30- 4:05 P.....	1,200	710	.57	1.3	0.2	19.8	78.7	.....	.....	
4:10- 4:45 P.....	.....	648	.57	0.9	0.2	19.9	79.0	4:15 P.	75	Firing discontinued 4:00 P. M.
Average	1,283	689	0.63	1.6	0.1	19.1	79.2			

Refuse Destroyed. During this test, 7,830 pounds of garbage and 1,775 pounds of rubbish were destroyed. The entire quantity of garbage was contained within the cell when the fuel fires were started and the rubbish was introduced during the day as follows:

Time.	*Weight of Rubbish (Pounds).*
9:00 A.	300
10:10 A.	200
2:20 P.	400
2:40 P.	400
2:50 P.	400
4:15 P.	75

The garbage destroyed was entirely kitchen refuse containing a high percentage of moisture, and in comparison with the garbage of other cities of Ohio, a large quantity of rubbish. A composite sample of the material was collected at the time of dumping, and its analysis was as follows:

Moisture	75 per cent.
Ash	3.59 per cent.
Combustible	20.91 per cent.
Ether extract	4.15 per cent.
Phosphoric acid, P_2O_5	0.20 per cent.
Kjeldahl nitrogen	0.57 per cent.
Potash, K_2O	0.27 per cent.
Calorific value, B. T. U.	2,100

Inasmuch as all the garbage was introduced into the furnace previous to the starting of the fires, it had no effect upon the temperature. The introduction of rubbish required but a small period of time, not exceeding one minute to each charge, and the cooling of the furnace brought about by this operation was not appreciable.

Use of Fuel and Methods of Firing. The firing of the furnace was cared for by the operator at the plant. According to usual custom, the fires were started with the use of about 150 pounds of wood to each fire box, and coal was used thereafter. A sample of the coal contained 89.93 per cent. moisture and combustible matter and 10.07 per cent. ash.

The firing was faulty in that the fuel was applied in large quantities at infrequent intervals, and very little attention was given to keeping the grates free of clinkers and the fuel beds level, covering the grates uniformly. Air holes in the fires were numerous, therefore, and prevented the production of the maximum temperature.

Stoking. No stoking was done during the first three hours of the test while the furnace was heating up and before combustion had actually started to take place. Between 11:30 A. M. and 5:30 P. M., however, stoking was done at intervals averaging 30 minutes. For this purpose the furnace doors were open during a total period of 40 minutes, equiv-

alent to 15 per cent. of the length of the test. In the latter portion of the day the dried garbage was removed to the fuel fires, as has been previously outlined. By this means the garbage was made to act as a fuel and served this purpose after 4:00 P. M., at which time the last coal was used.

Temperatures. After the starting of the fires, the temperatures in the furnace increased very slowly. After two hours of firing, the average temperature of the cell was only 500 degrees F. At this time the first observations were recorded. The temperatures maintained over the fuel fires throughout the test were very much lower than is required to secure the proper destruction of the garbage. The maximum temperature recorded was 1390 degrees, and it is probable that at no time during the test was the temperature greater than 1500 degrees. The temperature produced within the cell at all times during the test was very low, the maximum, 895 degrees, being recorded toward the end of the day. The average of all readings taken within the cell was 689 degrees, which is entirely too low for proper combustion. No measurement of the temperature of the flue gas was possible, but it is likely that the large dilution of air apparent in the flue gas analyses tends to keep the temperature of the flue gases very low.

Draft. The chimney draft was indicated by draft gages placed at the base of the stack. The indicated strength of the draft at all times was satisfactory, but within the furnace visual observation did not indicate that all of the gases passing up the stack were drawn through the grate openings. It is probable that a large leakage of air through the doors of the furnace and into the stack flue occurred. It is obviously impossible to secure proper draft conditions operating each cell independently, owing to the arched opening between the cells, which will always permit the passage of large volumes of cold air from the idle furnace. This was undoubtedly the case during this test, as well as the succeeding one, and presents a logical reason for the low temperatures within the furnace.

Flue Gas Analyses. At intervals throughout the test samples were collected from the base of the stack and analyzed in an Orsat apparatus at the plant. These analyses do not form a basis for judgment of the quality of the products of combustion, but, as would be expected, represent a very great dilution by air, which reaches the stack, as previously described. The average of seven analyses collected between 11:20 A. M. and 4:45 P. M. indicates the following:

CO_2, 1.6 per cent.; O_2, 19.1 per cent.; CO, 0.1 per cent.

Odors. Within the plant, especially on the lower floor, no odors were noted. On the charging floor odors were apparent only while the garbage was being dumped. These odors were not penetrating and probably could not be noted at a great distance. No observations were

made at distances away from the plant during the test. On the day previous, however, very objectionable odors were noted in the down town business district of the city. Inquiry failed to reveal the fact that serious complaint against the objectionable odors is made by persons residing or engaged in business in the vicinity. During the test the gases leaving the stack were observed at intervals. The characteristic light-colored garbage smoke was noted during the latter half of the test, but was not in evidence before that time.

Ashes from Refuse. The ashes from the refuse and from the fuel were taken from the furnace together and no separation was possible. With the assumption that the ashes and unburned material produced by the fuel was 12 per cent. of the fuel used, the weight of the ashes from the refuse was calculated to be 888 pounds. This represents 9.2 per cent. of the total refuse destroyed. It was possible to obtain a fair sample of the garbage ash, and its analysis showed the presence of 12.45 per cent. combustible matter.

TEST OF SEPTEMBER 24, 1909.

For this test, cell No. 2 of the furnace, which was idle the preceding day, was employed. At the time of starting, the cell was cold and contained 6400 pounds of garbage. The fires were started at 8:30 a. m., and were used continuously until 2:30 p. m., when it was apparent that no more coal would be required to complete the combustion of the garbage. The garbage had apparently completely burned at 3:30 p. m., when the test was concluded. After the furnace had cooled the ashes were removed and weighed. Table No. 96 contains the principal observations made during the test.

TABLE NO. 96.

OBSERVATIONS DURING CREMATORY TEST AT STEUBENVILLE SEPTEMBER 24, 1909.

Period.	Aver. Temp. Fuel Fires.	Aver. Temp. of Furnace.	Draft.	Flue Gas Analyses.				Rubbish Introduced.		Remarks.
				CO_2	CO	O_2	N.	Time	Weight. (lbs.)	
9:30–10:10 A.....	.....	757	.57	2.1	0.0	18.0	79.9	.....	.....	Fires started 8:30 A. M. Furnace contained 6400 pounds of garbage.
10:15–11:15 A.....	1,185	809	.60	2.0	0.0	18.5	79.5	11:20 A	250	
11:25A–12:25 P.....	.....	780	.60	2.2	0.0	18.4	79.4	.....	.....	
12:45–2:25 P.....	940	524	.51	0.8	0.0	20.1	79.1	.....	.....	
2:50–3:20 P.....	.....	731	.43	0.6	0.0	20.6	78.8	3:10 P	500	Firing discontinued 2:30 P. M.
3:35–3:40 P.....	.....	850	.....	.....	.....	.....	.....	.....	.....	
Average	1,012	742	.54	1.5	0.0	19.1	79.4	.....	.....	

Refuse Destroyed. During this test, 6400 pounds of garbage and 750 pounds of rubbish were burned. The entire quantity of garbage was placed within the cell before the fires were started. The rubbish was introduced during the test as follows:

Time.	*Weight of Rubbish.*
11:20 A. M.	250 pounds
3:10 P. M.	500 pounds

The garbage was entirely of household origin of about the same appearance as that destroyed on the preceding day. A composite sample collected at the time of dumping gave the following analysis:

Moisture	76.6 per cent.
Ash	2.85 per cent.
Combustible	20.55 per cent.
Ether extract	2.73 per cent.
Phosphoric acid, P_2O_5	0.14 per cent.
Kjeldahl nitrogen	0.54 per cent.
Potash, K_2O	0.29 per cent.
Calorific value, B. T. U.	1,990

The rubbish was entirely combustible matter, consisting largely of wood and paper. Its introduction into the cell was quickly accomplished and resulted in no appreciable cooling.

Use of Fuel and Method of Firing. The same quality of fuel was used and practically the same conditions of firing were maintained during this test as on the preceding day. The coal was added in quantities averaging 136 pounds for each fire at intervals averaging 50 minutes. The fires were not kept clinkered, the fuel beds were not maintained level, or the grates completely covered.

Stoking. From 9:40 a. m. until 3:00 p. m., the garbage was stoked frequently at intervals averaging 30 minutes, and the furnace was open for this purpose a total of 62 minutes, or 14 per cent. of the length of the test. Toward the latter portion of the day the garbage was removed from the primary grates and burned out upon the evaporating floor and in the fireboxes themselves.

Temperatures. In general the temperature conditions corresponded to those of the previous day. The heating of the cell took place very slowly and satisfactory temperatures were not obtained at any time during the day. The temperatures in the fire boxes were so low that proper combustion of the garbage was not possible. The maximum temperature within the cell was 850 degrees, occurring toward the end of the test, and the average temperature was 742 degrees. No flue temperatures were taken.

Draft. As during the preceding test, the indicated draft was satisfactory, but observation of the cell indicated improper draft conditions

within it. Only at the end of the furnace near the flue was a noticeably strong draft apparent.

Flue Gas Analyses. The flue gas samples, collected at intervals during the test, indicated in general the same results as those of the preceding day. A very large dilution by air was shown. The average of the six analyses gave the following percentages: CO_2, 1.5; O_2, 19.1; CO. 0; nitrogen, 79.3.

Ashes from Refuse. The ashes taken from the furnace were mixed and the garbage ash was estimated to weigh 726 pounds. This represents 10.2 per cent. of the original weight of the refuse destroyed. The ashes from the material had about the same appearance as those produced on the previous day, being of a dark grayish color and possessing a slight odor.

ZANESVILLE.

Tests were conducted at the garbage crematory at Zanesville on August 26 and 27, 1909, and on April 22, 1910, for the purpose of observing the results accomplished under ordinary operating conditions. The general conditions attending each of these tests were essentially the same, and the methods of operation were those commonly employed at the plant. The first test included the cremation of one day's collection of garbage; the second test, one-half day's collection; and the third test, one and one-half day's collection. In table No. 97 the principal items relating to the conditions and results of the tests are given.

TABLE NO. 97.

DATA ON CREMATORY TESTS AT ZANESVILLE.

	1909 Aug. 26	1909 Aug. 27	1910 April 22
Duration of test (hours)	7.67	7.0	8.3
Quantity of garbage destroyed (lbs.)	15,200	7,700	12,970
Quantity of mixed garbage and rubbish destroyed (lbs.)	1,450	3,325	3,755
Quantity of total refuse destroyed (lbs.)	16,650	11,025	16,725
Time required to burn garbage (hours)	7.67	7.0	8.3
Quantity of garbage destroyed per hour (lbs.)	1,982	1,100	1,562
Quantity of total refuse destroyed per hour (lbs.)	2,171	1,575	2,015
Quantity of garbage destroyed per hour per sq. ft. grate area (lbs.)	20.3	11.3	16.0
Quantity of total refuse destroyed per hour per sq. ft. grate area (lbs.)	22.3	16.2	20.7
Average percentage moisture in garbage	83.5	84.0	79.4
Weight of ashes remaining (lbs.)*	518	685	689
Per cent ashes of total weight of refuse	3.1	6.2	4.1
Coal used in garbage cell (lbs.)	3,035	2,257	3,961
Wood used in garbage cell (lbs.)	2,132	1,700	2,646
Equivalent coal used in garbage cell (lbs.)	4,058	3,072	5,230
Equivalent coal used in garbage cell per hour (lbs.)	529	439	630
Equivalent coal used in garbage cell per hour per sq. ft. grate area (lbs.)	5.4	4.5	6.5
Equivalent coal used in garbage cell per pound of garbage (lbs.)	.267	.399	.403
Equivalent coal used in garbage cell per pound total refuse destroyed (lbs.)	.244	.270	.313
Heating value of coal (B. T. U.)	11,256	11,256	11,374
Heating value of wood (B. T. U) (estimated)	5,400	5,400	5,400
Heating units in fuel used per pound of garbage (B. T. U.)	3,005	4,491	4,536
Heating units in fuel used per pound of total refuse (B. T. U.)	2,746	3,039	3,398
Fuel cost per ton of garbage destroyed	$0.60	$0.91	$1.01
Fuel cost per ton of total refuse destroyed	0.55	0.64	0.78
Coal used in gas consuming furnace (lbs.)	279	204	1,300
Number of hours in use	6.33	4.25	7.0
Coal used in gas consuming furnace per hour (lbs.)	44	48	186
Coal used in gas consuming furnace per hour per sq. ft. grate area (lbs.)	5.3	5.8	22.4
Coal used in gas consuming furnace per hour, per pound of garbage (lbs.)	.018	.027	.10
Total equivalent coal used per ton garbage (lbs.)	570	852	1,006
Total equivalent coal used per ton total refuse destroyed (lbs.)	520	594	780
Average temperature garbage cell, degrees F.	550	760	737
Max. temperature, garbage cell, degree F.	743	1,680	1,250
Average flue temperature, degrees F.	514	674	688
Average furnace room temperature, degrees F.	94	90	73

*Ashes from fuel and garbage weighed together. Garbage ash estimated. Ashes from fuel 7 per cent total coal.

TEST OF AUGUST 26, 1909.

On the day previous to this test the furnace was thoroughly cleaned and on the morning of August 26, before starting the fires, its temperature was but slightly above that of the air. The fuel bed was placed within the furnace at 5:30 A. M. Immediately over the grates a layer of coal, 4 to 6 inches in thickness, was placed, 2535 pounds of coal being used for this purpose. Above the coal, heavy cord wood was placed in a layer 18 inches in thickness. The wood used for this purpose weighed 1800 pounds. In addition, 333½ pounds of light kindling was used for starting the fire.

At 7:00 A. M. the fires in the gas consuming furnace were started and immediately afterward the fuel in the main furnace was ignited at several points. After the starting of the fires three loads of garbage (7650 pounds), which had been collected during the previous day, were dumped through the central charging holes, directly into the furnace. The greater portion of the garbage rested upon the tubular V-shaped grates, but a large quantity passed the tubular grates and banked the fuel bed below. This retarded the fire and the fuel burned only at the points where it was originally ignited. It was necessary to add coal at these points at various times and stoke the garbage to them to prevent the formation of large holes in the fuel bed. Following the introduction of this first charge of garbage, the fires progressed slowly, increasing gradually in intensity, but did not attain a high temperature. Miscellaneous refuse was dumped into the cell at various times during the morning, but the quantities were rather small and probably had no effect in retarding the fire. A second charge of three loads of garbage (7550 pounds) was placed within the furnace from 10:00 to 10:30 A. M. This cooled the furnace about 300 degrees and increased appreciably the thickness of the layer of garbage over the fuel bed. Up to this point the fuel had burned out but slightly and was ignited only along the ends of the furnace where the fires had originally been started. The increase in temperature was very slow and irregular until the latter portion of the test, when the remaining fuel and the dried garbage burned out rapidly, producing a fairly high temperature. The test was concluded at 2:40 P. M., at which time the fires died down. Table No. 98 contains the principal observations made during this test.

TABLE NO. 98.

OBSERVATIONS DURING CREMATORY TEST AT ZANESVILLE, AUGUST 26, 1909.

Period.	Av. Temp. in Garbage Cell.	Av. Temp. in Flue Leading to Gas Consumer.	Temp. Over Fires in Gas Consumer.	Draft in Flue from Cell.	Flue Gas Analyses.				Refuse Introduced.			Remarks.
					CO_2	O_2	CO	N.	Time.	Weight. (lbs.)	Class.	
8:00 - 9:00 A.	429	.....	710	.....	1.5	18.0	0.1	80.4	7:00 A.....	7,650	Garbage.	Fires started at 7:00 A. M.
9:00–10:00 A.	632	530	755	.51	4.8	14.7	0.4	80.1	7:20–7:30 A.	750	Mixed refuse.	
10:30–11:30 A.	534	.....	680	.56	1.9	19.3	0.3	78.5	8:15–8:30–			
12:30– 1:30 P.	740	485	880	.54	3.2	17.3	0.3	79.2	9:45 A.....	400	Mixed refuse.	
1:30– 2:00 P.	743	.....	.....	.....	3.7	15.8	0.2	80.3	10:00–10:35 A.	7,550	Garbage.	
2:00– 2:30 P.	500	680	635	.38	.....	.....	.....	.....	11:15 A.....	300	Mixed refuse.	Fires burned out at 2:40 P. M.
2:30– 2:40 P.	267	360	.....	.21	1.0	19.7	0.2	79.1				
Average	550	514	732	.44	2.7	17.5	0.2	79.6				

Refuse Destroyed. During the test, 15,200 pounds of garbage and 1450 pounds of mixed garbage and refuse were burned. The material was introduced into the furnace as follows:

Time.	Class of Refuse.	Weight (lbs.)	Remarks.
7:00 A....	Garbage	7,650	Three loads at beginning of test.
7:20 A....	Mixed refuse	150	
7:25 A....	Mixed refuse	300	
7:30 A....	Mixed refuse	300	
8:15 A....	Mixed refuse	200	
8:30 A....	Mixed refuse	100	
9.45 A....	Mixed refuse	100	
10.00 A....	Garbage	3,250	
10.15 A....	Garbage	2,600	
10:35 A....	Garbage	1,700	
11:15 A....	Mixed refuse	300	

The garbage delivered by the city wagons was very wet and was made up largely of potato parings, melon rinds, and corn husks. It contained very little rubbish. Its weight averaged 1288 pounds per cubic yard. The miscellaneous refuse was largely from commission houses and groceries, and was principally dry and easily combustible material. A composite sample of the garbage was collected and gave the following analysis:

Moisture	83.5 per cent.
Ash	2.27 per cent.
Combustible	14.23 per cent.
Ether extract	1.74 per cent.
Phosphoric acid, (P_2O_5)	0.15 per cent.
Kjeldahl nitrogen	0.30 per cent.
Potash, K_2O	0.25 per cent.
Calorific value, (B. T. U.)	1,331

All of the garbage and refuse was placed within the furnace directly, no attempt being made to employ the side hoppers for draining.

Use of Fuel and Methods of Firing. In addition to the fuel required to build the fuel bed, 500 pounds of coal were used during the test in the main incinerating furnace. This coal was added when necessary in order to replace that burned out from the fuel bed at points along the ends of the furnace where combustion was facilitated. In the gas consuming furnace, 279 pounds of coal were used. The use of coal in the gas consuming furnace was very irregular and the fires were maintained in poor condition. It should be noted that it is difficult to maintain the fires within the gas consuming furnace at a high temperature, owing to the fact that the excessive draft which passes directly over or

through the fire tends to create a large air excess which cools the products of combustion.

Stoking. During the test, at all times, except during the last 30 minutes, two men were employed almost constantly in stoking the garbage. The design and methods of operation of the furnace make this constant stoking necessary. The stoking consists principally in raking the garbage from the center of the cell to the ends. No burning takes place at the center of the furnace except at the end of the day; but at both ends of the furnace near the fire doors the fuel and garbage burn actively.

Temperatures. The results of the temperature measurements within the garbage cell indicate the poor results accomplished by the furnace. The average of all readings was 550 degrees, the maximum temperature, 743 degrees, being attained toward the end of the test. These temperatures are entirely too low for proper combustion. Moreover, the temperatures reached over the fires in the gas consuming furnace averaged only 732 degrees, and it is therefore apparent that these fires accomplished nothing in the way of completing the combustion and deodorizing the products from the main furnace.

Draft. No dampers for the control of the draft are provided, and its strength is, therefore, dependent upon temperatures. During the early portion of the test the draft through the main furnace was very low, owing to the blanketing effect of the garbage, which prevented the passage of air through the grates. The gas consuming furnace permits a large leakage of air into the flues through its various openings, and this is an explanation of the large air excess indicated by the flue gas analyses.

Flue Gas Analyses. Samples of the flue gas were taken at intervals during the test. No very wide fluctuation is shown in the composition of the flue gas during the greater portion of the test, and fairly constant conditions were maintained until the rapid burning of fuel garbage during the last half hour of the test. At this time the indicated quality of the combustion was much improved. The average of all flue gas analyses gave the following percentages: CO_2, 2.7; O_2, 17.5; CO, 0.2; nitrogen, 79.6.

Ashes from Garbage. The ashes from the fuel and garbage were mixed and it was impossible to weigh each separately. The total ashes were weighed, however, and with the former assumption that the fuel ash represents 7 per cent. of the total fuel, the weight of the garbage ash was calculated to be 518 pounds, representing 3.1 per cent. of the total refuse burned. This indicates very complete destruction. A sample of the mixed ashes was found to contain 8.8 per cent. moisture, 28.94 per cent. combustible, and had a calorific value of 2197 B. T. U.

TEST OF AUGUST 27, 1909.

No collection of garbage was made on the afternoon of August 26, and it was therefore impossible to begin the second test on August 27, in the early morning. The fuel bed was prepared as on the preceding day by the use of 1877 pounds of coal, 1521 pounds of cordwood, and 180 pounds of kindling. The fires were ignited in the main incinerating furnace and in the gas consuming furnace at 9:55 A. M., immediately previous to the introduction of 7700 pounds of garbage, which arrived at that time. The test was conducted similarly to the previous one and was concluded at 5:00 P. M., when the fuel and garbage had burned out completely. Table No. 99 contains the principal observations made during the test.

TABLE NO. 99.

OBSERVATIONS DURING CREMATORY TEST AT ZANESVILLE, AUGUST 27, 1909.

Period.	Av. Temp. in Garbage Cell.	Av. Temp. in Flue Leading to Gas Consumer.	Temp. over Fires in Gas Consumer.	Draft in Flue from Cell.	Flue Gas Analyses.				Refuse Introduced.			Remarks.
					CO_2.	O_2.	CO.	N.	Time.	Weight.	Class.	
10.00-10:30 A	257	.....	300	.19	.....	.....	.....	.....	7:30-10:10 A	3,225	Mixed refuse...	Fires started 9:55 A. M.
10:30-11:00 A	890	550	.....	.13	3.4	16.8	0.4	79.4	10:10-10:40 A	7,700	Garbage	
									10:50 A.....	100	Mixed refuse...	
11:00-11:30 A	637	260	495	.36	2.4	18.2	0.0	79.4				
11.30-12:00 N	608	.....	360	.31	2.3	17.9	0.2	79.6				
12:45- 1:15 P	614	600	735	.48	1.4	18.8	0.0	79.8				
1:30- 2:00 P	1,042	650	590	.45	3.6	16.8	0.3	79.3				
2:30- 3:30 P	645	630	895	.51	4.7	15.7	0.3	79.3				
3:50- 4:00 P	580	.....	.....	.....	6.3	16.2	0.1	77.4				
4:30 P.....	1,680	1,320	.....	.37	10.0	13.8	0.0	76.2				
5:00 P.....	645	710	.....	.37	.....	.....	.....	.....				Fires burned out at 5:00 P. M.
Average ...	760	674	562	.35	4.2	16.8	0.2	78.8				

Refuse Destroyed. During this test a total of 7700 pounds of garbage and 3325 pounds of mixed garbage and rubbish were destroyed. The refuse was introduced into the cell as follows:

Time.	Class of Refuse.	Weight (lbs.)	Remarks.
7:30–10:10 A.	Mixed garbage and rubbish	3,225	Principal portion introduced before fires were started.
10:10 A.	Garbage	2,900	
10:30 A.	Garbage	3,000	
10:40 A.	Garbage	1,800	
10:50 A.	Mixed garbage and rubbish	100	

The garbage was of about the same character as that burned on the previous day, being very wet and compact and consisting almost entirely of vegetable wastes. Its weight averaged 1305 pounds per cubic yard. The mixed refuse was of miscellaneous character, but the larger portion was dry and easily combustible. A composite sample of the garbage was collected and gave the following analytical results:

Moisture	84.0 per cent.
Ash	1.66 per cent.
Combustible	14.34 per cent.
Ether extract	1.64 per cent.
Phosphoric acid, P_2O_5	0.09 per cent.
Kjeldahl nitrogen	0.29 per cent.
Potash, K_2O	0.27 per cent.
Calorific value, B. T. U.	1,305

Use of Fuel and Methods of Firing. In addition to the fuel used in building the fuel beds, 380 pounds of coal were used in the main furnace to replace that burned out near the fire doors. In the gas consuming furnace 204 pounds of coal were used. The fires were maintained improperly as during the preceding test, and no high temperatures were produced. The coal used in both furnaces was of the same quality as that used on the preceding day.

Stoking. Throughout the test stoking was carried on frequently and, as during the preceding test, this required the almost constant attention of two men. The garbage was gradually removed from the central portion of the cell to the ends of the furnace, where combustion takes place.

Temperatures. In preparation for this test a larger amount of fuel, in proportion to the garbage, was used than on the preceding day, and the result was a somewhat higher average temperature within the furnace. The high temperatures did not, however, manifest themselves

until the latter portion of the day, when the fuel burned out rapidly. At this time a temperature of 1,680 degrees was recorded. An average, including all observations, was 760 degrees. The temperature of the flue gases, except at the end of the test, was below 700 degrees, and their temperatures were not increased appreciably by passing over the fires in the gas consuming furnace. Several observations showed that the temperatures over the fires in the gas consumer were at times lower than the temperatures of the flue gases themselves.

Draft. The draft conditions during this test were similar to those of the preceding one. The strength of the draft was entirely dependent upon temperature conditions and the facility of passage of air through the grates of the furnace. The draft was rather sluggish within the main furnace, except at the end of the test. The draft through the fires of the gas consuming furnace was, however, strong at all times and prevented the production of high temperatures at this point.

Flue Gas Analyses. During the test, eight samples of flue gas were analyzed. The analyses in general showed a large air excess in the flue gas, and the presence of CO indicates that this air excess reaches the flue through leaky points in the gas consuming furnace and does not originate by passage through the grate to the main furnace. In general, poor combustion is shown. The average of all the analyses gives the following percentages. CO_2, 4.2; O_2, 16.8; CO, 0.2; and nitrogen, 78.8.

Ashes from Furnace. The ashes from the fuel and refuse were weighed together, and upon the assumption that the fuel ash was 7 per cent. of the total fuel used, the garbage ashes were calculated to weigh 685 pounds. This represents 6.2 per cent. of the total refuse destroyed. While this figure is somewhat higher than that of the preceding test (3.1 per cent.), it should be noted that a much larger percentage of dry rubbish was received, from which a higher percentage of ash is produced. The ashes were finely divided, contained no visible unburned material, and had little odor.

TEST OF APRIL 22, 1910.

During this test the garbage and rubbish collected for one and one-half days was destroyed. The fuel bed was prepared on the morning of April 21 with the use of 3,221 pounds of coal, 2,120 pounds of cordwood, and 520 pounds of kindling. On April 21 the garbage and rubbish arriving at the plant was immediately dumped into the furnace, and at the time the fires were started, at 6:40 A. M. April 22, the furnace contained 8080 pounds of garbage and 2,515 pounds of mixed garbage and rubbish. The test was conducted according to the same methods of operation as obtained during the preceding ones. It was concluded at 3:00 P. M. April 22, when the refuse had been completely burned. Table No. 100 contains the principal observations made during the test.

TABLE NO 100.

OBSERVATIONS DURING CREMATORY TEST AT ZANESVILLE.

April 22, 1910.

Period.	Average Temp. in Garbage Cell.	Temp. in Flue Leading to Gas Consumer.	Temp. over Fires in Gas Consumer.	Temp. in Stack.	Draft in Flue Leading to Gas Consumer.	Draft at base of stack.	Flue Gas Analyses.				Refuse introduced.			Remarks.
							CO_2	O_2	CO	N.	Time.	Weight (lbs.)	Class.	
7:30 A	385				.29						7:00 A	200	Mixed Refuse	Fires started at 6:40 A. M.
8-8:10 A	500										8:00 A	35	Mixed Refuse	Cell contained 8,910 pounds garbage and 2,515 pounds of mixed refuse.
8:30-9 A	664		610	550	.31						8:15 A	170	Mixed Refuse	
9-9:10 A	5 5		1,160	550	.36		2.8	17.5	0.0	79.7				
9:50-10 A	820	360			.35		3.0	17.0	0.3	79.7				
10:20 A	780	505	1,370		.43		5.5	13.9	0.4	80.2				
11:00 A	525			600	.45		2.6	17.5	0.2	79.7	10:30-10-40 A	4,060	Garbage	
12:30-1 P	572			685	.35		2.7	17.5	0.1	79.7	11:00 A	700	Mixed Refuse	
1:30-2 P	1,242	1,200			.35		8.4	11.6	0.1	79.9				
2-2:10 P	1,250			800	.32		5.7	14.6	0.0	79.7				
2:40-2:50 P	861				.85		2.3	18.2	0.0	79.5	2:30 P	135	Mixed Refuse	Fires burned out at 3:00 P. M.
Average	737	688	1,057	637	.36		4.1	16.0	0.1	79.8				

Refuse Destroyed. During this test 12,970 pounds of garbage and 3,265 pounds of mixed refuse were destroyed. The entire collection of April 21, the day previous to the test, was introduced to the furnace upon its arrival, and the material rested upon the fuel bed during a period of twelve hours or more before the fires were started. This caused a dampening of the fuel and reduced its heating value appreciably. The garbage and mixed refuse were introduced into the furnace as follows:

Time.	Class of Refuse.	Weight.	Remarks.
April 21, 6:30 A. to 3:30 P.....	Mixed garbage and rubbish	2,515	Introduced on day previous to test.
April 21, 10:30 A. to 3:40 P.....	Garbage	8,910	Introduced on day previous to test.
April 22, 7:00 A.....	Mixed garbage and rubbish	200	
April 22, 8:00 A.....	Mixed garbage and rubbish	35	
April 22, 8:15 A.....	Mixed garbage and rubbish	170	
April 22, 10:30 A.....	Garbage	1,640	
April 22, 10:40 A.....	Garbage	2,420	
April 22, 11:00 A.....	Mixed garbage and rubbish	700	
April 22, 2:30 P.....	Mixed garbage and rubbish	135	

The garbage destroyed during this test was very wet and compact and consisted almost entirely of spring vegetable wastes. It contained only a small amount of rubbish. Its weight averaged 1,168 pounds per cubic yard. The miscellaneous refuse was largely commission and grocery wastes and was in a large measure dry and easily combustible. A sample of the garbage was collected at the time of dumping and gave the following analytical results:

Moisture	79.4 per cent.
Ash	3.49 per cent.
Combustible	17.11 per cent.
Ether extract	2.45 per cent.
Phosphoric Acid, P_2O_5.....	0.14 per cent.
Kjeldahl nitrogen	0.46 per cent.
Potash K_2O	0.31 per cent.
Calorific value (B. T. U.).....	1,611.

Use of Fuel and Methods of Firing. In addition to the fuel used in starting, 740 pounds of coal were added to the fires in the main cell, and 1,300 pounds in the gas consuming furnace. The firing of the gas consumer was very much more regular than during the preceding tests and generally higher temperatures were created. The effect of a strong draft upon the fires was noted, however, and it is apparent that it is im-

possible to produce steady and high temperatures within the furnace. The fires in the gas consuming furnace were allowed to die down about one hour before the end of the test. The coal used was of good quality, burning with a small amount of clinker. Its calorific value was 11,374 B. T. U. The wood was rather green cordwood of various kinds.

Stoking. Stoking was carried on very frequently, as observed in the preceding test. A record of the stoking during this test showed that the furnace received attention at intervals of thirteen minutes during the entire day.

Temperatures. Within the garbage cell no high temperatures were reached until 1:30 P. M., about one hour before the end of the test. At this time the maximum temperature of the cell was recorded. The average of all readings taken was 737 degrees, and the maximum was 1,250 degrees. The temperature of the flue gases was below 700 degrees during the greater portion of the test, and comparative temperatures, taken before and after passing through the gas consumer, did not indicate an appreciable increase by passage over the fires in the furnace. During this test a total of 1,275 pounds of water were evaporated in the crown, and the maximum steam pressure attained was 45 pounds per square inch, at 2:00 P. M.

Draft. The same improper draft conditions noted in previous tests obtained during this test. Measurements in the flues leading from the main furnace indicated a fairly strong draft varying from .30 to .45 inch, while at the base of the stack a measurement of .85 inch was recorded at the end of the test. This indicates a large leakage of air through the fires and other openings in the gas consuming furnace and explains the presence of a large percentage of air in the flue gas analyses, as well as the failure of the gas consumer to raise the temperature of the products of combustion.

Flue Gas Analyses. During the test eight samples of flue gas were analyzed. The results are comparable to those obtained during the preceding tests and indicate the same general improper combustion with the presence of a large air excess. The average of the analyses is as follows: CO_2, 4.1 per cent.; O_2, 16.0 per cent.; CO, 0.1 per cent.; and nitrogen, 79.8 per cent.

Ashes from Furnace. Using the same assumption governing the calculation for the weight of garbage ash produced as was used for the preceding tests, the ash from the garbage and refuse during this test weighed 689 pounds. This is equivalent to 4.1 per cent. of the total refuse burned. The ash was finely divided, possessed no odor, and was apparently well burned.

SUMMARY.

The studies of disposal of garbage by incineration in the various cities of Ohio demonstrate interesting facts, the most salient of which are as follows:

1. The plants as operated fail usually to dispose of the garbage at a temperature high enough to avoid the production of odors.

2. The cost of operation is excessive.

In table No. 101 are given summarized temperature observations made at the plants working under ordinary operating conditions. It will be noted that in only one case, at Mansfield, was the average temperature as high as 1000 degrees. The maximum temperatures at Zanesville occurred at the end of the test, when the fuel and dried garbage burned quickly and are not, strictly speaking, to be included as maximum temperatures of operation.

TABLE NO. 101.

TEMPERATURES, WITH ORDINARY OPERATION, WITHIN COMBUSTION CELLS OF GARBAGE CREMATORIES.

City.	Date of Observation.	Average Temp. During Observations, Deg. F.	Maximum Temp. During Observations, Deg. F.
Canton	July 29, 1909	538	1,065
	February 23, 1910	972	1,335
Mansfield	November 18-19, 1909	1,002	1,430
Marion	October 28-29, 1909	803	1,140
Steubenville	September 23, 1909	689	895
	September 24, 1909	742	850
Zanesville	August 26, 1909	550	743
	August 27, 1909	760	1,680
	April 22, 1910	737	1,250

In table No. 102 is given a comparison of fuel consumption, obtained from tests made at the various plants. It will be noted that the fuel consumption is excessive at all of the plants. At Mansfield the economy was greatest, and it is interesting to note that the temperatures at this plant were the most satisfactory.

TABLE NO. 102.

COMPARISON OF FUEL CONSUMPTION. GARBAGE CREMATORY TESTS.

City.	Lbs. Equiv. Coal per Ton Refuse Destroyed.	B. T. U's in Fuel used per lb. Refuse.	Fuel Cost per Ton Refuse.	Character of Refuse.		
				% Garbage.	% Mixed Garbage.	% Night Soil.
Canton	730	4,011	$0.68	100	.....	.....
Mansfield	362	2,284	0.34	100	.....	.....
Marion	370*	3,355	0.91	31.7	11.7	56.6
Steubenville	642	4,052	0.60	86.	14.	.....
Zanesville	631	3,061	0.66	81.	19.	.....

* Coal equivalent of gas — 15 cubic feet gas = one lb. coal.

APPENDICES II TO VII.

In the following appendices, Nos. III to VII, are presented tables Nos. 103 to 150, which contain principally the analytical data secured during the study.

Appendix No. III presents results of examination of the composition of garbage. In tables Nos. 103 to 106 are the analyses of all of the composite samples collected at Cleveland, Cincinnati, Columbus and Dayton. These include a number of duplicate samples, and it is interesting to note the failure to secure check results in certain of the constituents, due to the impossibility of securing true average samples. In tables Nos. 107 to 110 the results of tables Nos. 103 to 106, respectively, are presented after calculation to the dry basis. Table No. 111 contains analyses of garbage from the smaller cities of the state. In tables Nos. 112 to 115 is shown the monthly variation in the analyses of garbage from the four large cities of the state. These monthly results are averages of the results of tables Nos. 103 to 106. Tables Nos. 116 to 119 contain the figures of tables Nos. 112 to 115 calculated to the dry basis. These tables, it will be noted, indicate no regular or accountable fluctuations in the constituents. In tables Nos. 120 to 122 are given results indicating the daily variation in analyses of garbage at Cleveland, Columbus and Dayton. Tables Nos. 123 to 125 contain the results on the dry basis. The analyses of special samples representing high class residential, low class residential, and hotel garbage are contained in table No. 126. Tables Nos. 127 and 128 contain analyses of composite samples of garbage from Dayton. These samples were taken at the reduction plant from a paper mill beater, a machine installed and used for a time to grind the garbage before drying. These samples, it is thought, are the most representative ones collected, as all of the constituents contained in the garbage excepting the rubbish, metal, etc., were included in the sample. The very good mixture of the mass, brought about by its passage through the beater, assisted in the securing of a fair sample. It will be noted that the phosphoric acid and nitrogen determinations are materially higher than in the analyses of the regularly collected composite samples from Dayton.

Appendix IV contains results of examination of garbage tankage. Tables Nos. 129, 130 and 131 contain analyses of tankage from Cleveland, Cincinnati and Dayton, respectively.

In Appendix V are given results of examination of the composition of rubbish and ashes. Tables Nos. 132, 133 and 134 present the results of hand separation of loads of mixed rubbish and ashes at Cleveland,

Cincinnati and Dayton; and in Tables Nos. 135, 136 and 137 the percentages of the rubbish constituents are revised, after deducting the ashes, in order to show the true composition of the rubbish. Tables Nos. 138, 139 and 140 contain analyses of composite samples of ashes from Cleveland, Cincinnati and Dayton.

Appendix VI contains miscellaneous analyses. Table No. 141 gives the composition of street cleanings; table No. 142 contains analyses of coal used in crematory tests; and in table No. 143 are presented analyses of ashes from garbage crematories.

Appendix VII contains tables showing the unit weight of garbage and rubbish-ashes. In tables Nos. 144 to 147 are given the weights of garbage during the months of the year 1909 at Cleveland, Columbus and Dayton; and tables Nos. 148 to 150 give the weights of rubbish-ashes obtained during the studies at Cleveland, Cincinnati and Dayton.

APPENDIX III.

COMPOSITION OF GARBAGE.

ANALYSES OF COMPOSITE SAMPLES.

MONTHLY VARIATION.

DAILY VARIATION.

ANALYSES OF SPECIAL SAMPLES.

ANALYSES OF COMPOSITE SAMPLES FROM BEATER AT DAYTON.

TABLE NO. 103.

RESULTS OF ANALYSES OF COMPOSITF GARBAGE SAMPLES.

Cleveland.

Sample Number.	Date of Collection.	No. of Loads Included.	Average Weight per Cubic Yard.	Percentages.			Calorific Value B. T. U.	Percentages.			
				Moisture.	Ash.	Combustible Matter.		Ether Extract.	Phosphoric Acid as P_2O_5.	Nitrogen Kjeldahl Method.	Potash as K_2O.
23	May 14, '09	60	1,322	72.8	3.37	23.83	2,266	4.60	0.31	0.72	0.32
24	May 14, '09	60	1,322	72.5	3.64	23.86	2,258	4.48	0.33	0.73	0.37
51	June 15, '09	89	1,519	75.7	3.62	20.68	2,015	4.22	0.32	0.63	0.31
52	June 15, '09	89	1,519	75.6	3.60	20.80	2,013	4.28	0.26	0.67	0.30
53	June 16, '09	82	1,428	76.8	3.19	20.01	1,966	3.89	0.19	0.62	0.31
54	June 17, '09	21*	1,420	74.6	3.08	22.32	2,238	5.12	0.30	0.83	0.30
55	June 18, '09	88	1,545	77.1	2.80	20.10	2,024	4.56	0.20	0.60	0.32
56	June 18, '09	88	1,545	76.8	2.94	20.26	2,012	4.43	0.21	0.62	0.39
57	June 19, '09	84	1,366	75.7	3.01	21.29	2,106	4.70	0.21	0.60	0.29
58	June 21, '09	90	1,439	75.2	3.82	20.98	2,076	4.33	0.31	0.66	0.29
71	July 20, '09	80	1,371	76.3	3.10	20.60	2,056	4.58	0.29	0.62	0.27
72	July 20, '09	80	1,371	76.4	3.09	20.41	2,063	5.19	0.26	0.66	0.25
84	August 19, '09	110	1,204	78.4	2.64	18.96	1,884	3.88	0.19	0.53	0.29
93	September 16, '09	66	1,196	78.9	2.84	18.26	1,808	3.46	0.20	0.56	0.31
103	October 14, '09	101	1,412	75.6	2.96	21.44	2,070	3.60	0.34	0.65	0.28
113	November 10, '09	90	1,482	76.7	3.00	20.30	2,024	4.04	0.23	0.63	0.30
139	December 13, '09	104	1,502	76.0	3.07	20.93	2,047	3.47	0.26	0.61	0.19
140	December 14, '09	98	1,467	74.2	3.80	22.00	2,177	4.30	0.32	0.64	0.23
141	December 15, '09	91	1,375	75.7	3.26	21.14	2,048	3.54	.....	0.58	0.28
143	December 16, '09	89	1,290	75.2	2.86	21.94	2,119	3.71	0.26	0.65	0.28
145	December 17, '09	92	1,158	75.0	3.12	21.88	2,146	3.72	0.25	0.63	0.34
146	December 18, '09	74	960	75.1	2.97	21.93	2,094	3.37	0.19	0.65	0.33
161	January 21, '10	86	1,194	76.1	3.00	20.90	2,086	3.80	0.23	0.68	0.25
180	February 18, '10	85	1,065	75.9	2.63	21.47	2,110	3.59	0.25	0.64	0.26
195	March 10, '10	87	1,428	72.7	3.58	23.72	2,264	3.78	0.18	0.68	0.32
203	April 11, '10	106	1,374	74.3	3.60	22.01	2,095	3.58	0.18	0.63	0.34
225	May 12, '10	87	1,415	73.3	4.02	22.68	2,106	3.68	0.22	0.63	0.30
229	June 2, '10	87	1,588	76.9	3.42	19.68	1,874	2.89	0.25	0.62	0.31

Duplicate Samples: 23-24, 51-52, 55, 56 and 71-72.
* Sampling stopped at noon. Morning loads include all hotel garbage.

TABLE NO. 104.

RESULTS OF ANALYSES OF COMPOSITE GARBAGE SAMPLES.

Cincinnati.

Sample Number.	Date of Collection.	No. of Loads Included.	Average Weight per Cubic Yard.	Percentages.			Calorific Value B. T. U.	Percentages.			
				Moisture.	Ash.	Combustible Matter.		Ether Extract.	Phosphoric Acid as P_2O_5.	Nitrogen Kjeldahl Method.	Potash as K_2O.
91	September 9, '09	93	1,493	79.3	3.03	17.67	1,771	3.22	0.31	0.58	0.23
101	October 7, '09	101	1,205	76.3	3.01	20.69	2,092	4.23	0.33	0.68	0.30
111	November 5, '09	58	1,212	75.9	3.32	20.78	2,215	5.46	0.24	0.61	0.30
134	December 8, '09	34	1,153	77.4	3.65	18.95	1,892	3.28	0.23	0.58	0.23
148	January 7, '10	44	1,167	78.3	3.32	18.38	1,849	3.51	0.24	0.57	0.27
169	February 8, '10	48	1,102	76.8	3.92	19.28	1,935	3.94	0.44	0.63	0.28
187	March 3, '10	60	1,292	75.6	3.70	20.70	2,096	4.22	0.36	0.65	0.21
200	April 7, '10	64	1,230	75.9	3.71	20.39	2,018	3.94	0.34	0.68	0.29
216	May 3, '10	59	1,198	74.5	4.12	21.38	2,176	4.46	0.26	0.72	0.34
232	June 6, '10	67	1,223	76.4	4.80	18.80	1,952	3.87	0.17	0.69	0.31

TABLE NO. 105.

RESULTS OF ANALYSES OF COMPOSITE GARBAGE SAMPLES.

Columbus.

Sample Number.	Date of Collection.	No. of Loads Included.	Average Weight per Cubic Yard.	Percentages.			Calorific Value B. T. U.	Percentages.			
				Moisture.	Ash.	Combustible Matter.		Ether Extract.	Phosphoric Acid as P_2O_5.	Nitrogen Kjeldahl Method.	Potash as K_2O.
27	May 17, '09	38	1,177	73.0	4.03	22.67	2,244	5.17	0.21	0.68	0.25
28	May 17, '09	38	1,177	73.3	4.16	22.54	2,229	5.08	0.28	0.66	0.25
40	June 1, '09	41	1,302	76.7	3.40	19.80	1,980	4.12	0.17	0.56	0.29
41	June 1, '09	41	1,302	78.0	3.31	18.69	1,825	3.65	0.14	0.56	0.26
42	June 2, '09	36	1,284	77.5	3.47	19.03	1,861	3.66	0.17	0.66	0.28
43	June 3, '09	40	1,302	77.8	3.50	18.70	1,831	3.90	0.37	0.59	0.31
44	June 3, '09	40	1,302	78.1	3.54	18.36	1,763	3.69	0.19	0.55	0.28
45	June 4, '09	35	1,311	77.1	3.31	19.59	1,928	3.92	0.35	0.61	0.30
46	June 5, '09	30	1,342	78.0	3.30	18.70	1,832	4.15	0.29	0.58	0.25
47	June 5, '09	30	1,342	76.5	3.32	20.18	2,101	5.70	0.20	0.62	0.28
59	July 6, '09	45	1,316	77.9	3.51	18.59	1,846	3.92	0.22	0.55	0.28
60	July 6, '09	45	1,316	77.9	3.60	18.50	1,839	3.95	0.14	0.52	0.30
80	August 3, '09	49	1,206	79.0	2.97	18.03	1,768	3.45	0.21	0.50	0.26
81	August 3, '09	49	1,206	80.4	3.12	16.48	1,591	3.10	0.44	0.43	0.23
90	September 7, '09	58	1,216	79.6	2.50	17.90	1,738	3.03	0.15	0.53	0.23
104	October 4, '09	48	1,232	77.3	3.14	19.56	1,894	3.44	0.24	0.60	0.18
110	November 1, '09	43	1,289	76.3	3.09	20.61	1,984	3.87	0.22	0.55	0.26
124	November 29, '09	51	1,295	75.7	3.20	21.10	2,070	3.70	0.26	0.63	0.20
125	November 30, '09	41	1,251	74.6	3.45	21.95	2,148	4.18	0.41	0.65	0.22
126	November 30, '09	41	1,251	74.7	3.24	22.06	2,145	4.11	0.33	0.64	0.26
127	December 1, '09	51	1,227	74.3	3.84	21.86	2,174	4.34	0.34	0.66	0.24
128	December 2, '09	47	1,221	74.9	3.29	21.81	2,147	4.03	0.29	0.57	0.27
129	December 3, '09	38	1,252	76.9	3.44	19.66	1,923	3.64	0.30	0.58	0.25
130	December 3, '09	38	1,252	77.1	3.33	19.57	1,908	3.56	0.20	0.62	0.29
131	December 4, '09	38	1,202	76.7	3.28	20.02	2,055	3.95	0.34	0.63	0.28
147	January 4, '10	44	1,022	74.1	2.78	23.12	2,289	4.51	0.23	0.58	0.27
163	January 31, '10	38	1,072	76.3	2.60	21.10	2,091	4.25	0.17	0.57	0.26
185	February 25, '10	30	813	76.8	2.43	20.57	2,019	4.00	0.09	0.52	0.23
198	April 4, '10	41	1,222	73.9	4.61	21.49	2,139	4.19	0.23	0.68	0.23
220	May 6, '10	42	1,120	76.2	3.65	20.15	1,987	3.46	0.22	0.61	0.32
227	May 28, '10	34	1,213	75.4	3.92	20.68	2,046	4.31	0.26	0.72	0.24

Duplicate Samples: 27-28, 40-41, 43-44, 46-47, 59, 60, 80-81, 125-126 and 129-130.

TABLE NO. 106.

RESULTS OF ANALYSES OF COMPOSITE GARBAGE SAMPLES.

Dayton.

Sample Number.	Date of Collection.	No. of Loads Included.	Average Weight per Cubic Yard.	Percentages.			Calorific Value B. T. U.	Percentages.			
				Moisture.	Ash.	Combustible Matter.		Ether Extract.	Phosphoric Acid as P_2O_5.	Nitrogen Kjeldahl Method.	Potash as K_2O.
32	May 21, '09	15	1,639	80.0	3.15	16.85	1,728	4.27	0.23	0.53	0.20
33	May 21, '09	15	1,639	79.6	2.80	17.60	1,794	4.24	0.21	0.52	0.38
48	June 8, '09	21	1,512	80.5	2.51	16.99	1,795	4.93	0.23	0.54	0.19
49	June 8, '09	21	1,512	80.5	2.77	16.78	1,800	4.56	0.21	0.51	0.24
62	July 12, '09	26	1,590	81.5	2.48	16.02	1,601	3.50	0.17	0.47	0.17
63	July 12, '09	26	1,590	78.8	2.63	18.57	1,896	4.77	0.25	0.55	0.21
64	July 13, '09	23	1,530	82.9	2.46	14.64	1,480	3.32	0.17	0.45	0.25
65	July 14, '09	24	1,500	83.5	2.35	14.15	1,397	3.12	0.19	0.46	0.20
66	July 14, '09	24	1,500	83.3	2.53	14.17	1,381	3.18	0.18	0.43	0.20
67	July 15, '09	20	1,437	83.6	2.27	14.13	1,386	3.04	0.14	0.39	0.20
68	July 16, '09	23	1,558	82.7	2.24	15.06	1,515	3.52	0.26	0.44	0.21
69	July 16, '09	23	1,558	81.4	2.93	15.67	1,569	3.67	0.23	0.50	0.22
70	July 17, '09	21	1,527	83.4	2.43	14.17	1,378	2.95	0.16	0.41	0.20
82	August 17, '09	25	.....	83.1	1.96	14.95	1,512	3.10	0.16	0.41	0.18
83	August 17, '09	25	.....	81.2	2.15	16.65	1,675	3.48	0.18	0.41	0.17
92	September 13, '09	22	1,596	82.2	2.22	15.58	1,577	3.62	0.17	0.49	0.21
104	October 20, '09	20	1,642	83.0	2.00	15.00	1,513	3.11	0.16	0.47	0.19
105	October 20, '09	20	1,642	83.6	1.91	14.49	1,463	2.85	0.16	0.44	0.19
114	November 11, '09	20	1,536	82.5	2.22	15.28	1,559	3.47	0.18	0.48	0.22
135	December 8, '09	18	1,295	81.7	2.27	16.03	1,632	3.66	0.26	0.54	0.13
149	January 10, '10	18	1,061	77.6	3.49	18.91	1,988	4.51	0.24	0.57	0.17
151	January 11, '10	18	970	79.2	2.18	18.62	1,810	3.76	0.19	0.54	0.18
153	January 12, '10	18	1,169	80.0	2.08	17.92	1,808	4.03	0.18	0.49	0.16
157	January 13, '10	16	1,258	81.1	2.11	16.79	1,693	3.78	0.11	0.46	0.14
160	January 14, '10	18	1,346	81.5	2.23	16.27	1,676	3.58	0.14	0.49	0.16
175	February 15, '10	18	1,154	79.7	2.64	17.66	1,823	4.28	0.18	0.53	0.16
190	March 8, '10	18	1,523	77.9	2.99	19.01	1,927	4.38	0.29	0.55	0.15
212	April 26, '10	19	1,538	78.2	3.03	18.77	1,928	4.54	0.17	0.61	0.23
222	May 10, '10	22	1,551	79.1	2.69	18.21	1,959	3.74	0.16	0.57	0.22
237	June 10, '10	20	1,490	79.0	3.39	17.61	1,741	3.39	0.15	0.55	0.21

Duplicate Samples: 32-33, 48-49, 62-63, 65-66, 68-69, 82-83, and 104-105.

TABLE NO. 107.

RESULTS OF ANALYSES OF COMPOSITE GARBAGE SAMPLES.

Cleveland.

(Results Calculated on Dry Basis.)

Sample Number.	Date of Collection.	No. of Loads Included.	Percentages.		Calorific Value B. T. U.	Percentages.			
			Ash.	Combustible Matter.		Ether Extract.	Phosphoric Acid as P_2O_5.	Nitrogen Kjeldahl Method.	Potash as K_2O.
23	May 14, '09	60	12.39	87.61	8,333	16.93	1.15	2.64	1.77
24	May 14, '09	60	13.25	86.75	8,210	16.80	1.20	2.65	1.35
51	June 15, '09	89	14.88	85.12	8,294	17.33	1.26	2.59	1.26
52	June 15, '09	89	14.75	85.25	8,252	17.53	1.08	2.74	1.23
53	June 16, '09	82	13.73	86.27	8,475	16.77	0.81	2.68	1.32
54	June 17, '09	21	12.14	87.86	8,813	20.16	1.18	3.27	1.18
55	June 18, '09	88	12.23	87.77	8,888	19.91	0.88	2.61	1.38
56	June 18, '09	88	12.69	87.31	8,671	19.10	0.89	2.66	1.70
57	June 19, '09	84	12.40	87.60	8,666	19.84	0.88	2.45	1.20
58	June 21, '09	90	15.42	84.58	8,372	17.45	1.24	2.66	1.19
71	July 20, '09	80	13.08	86.92	8,674	19.33	1.22	2.63	1.13
72	July 20, '09	80	13.14	86.86	8,780	22.10	1.10	2.80	1.08
84	August 19, '09	110	12.23	87.77	8,721	17.96	0.87	2.46	1.34
98	September 16, '09	66	13.48	86.52	8,569	16.39	0.96	2.65	1.49
103	October 14, '09	101	12.13	87.87	8,486	14.77	1.38	2.67	1.15
113	November 10, '09	90	12.86	87.14	8,685	17.34	0.99	2.69	1.28
139	December 13, '09	104	12.80	87.20	8,580	14.47	1.07	2.55	0.81
140	December 14, '09	98	14.72	85.28	8,436	16.65	1.24	2.50	0.91
141	December 15, '09	91	13.36	86.64	8,428	14.52	.....	2.40	1.17
143	December 16, '09	89	11.54	88.46	8,544	14.98	1.04	2.61	1.14
145	December 17, '09	92	12.48	87.52	8,588	14.88	0.99	2.53	1.37
146	December 18, '09	74	11.94	88.06	8,408	13.52	0.77	2.61	1.31
161	January 21, '10	86	12.55	87.45	8,728	15.90	0.97	2.84	1.06
180	February 18, '10	85	10.90	89.10	8,756	14.89	1.05	2.64	1.10
195	March 10, '10	87	13.10	86.90	8,294	13.84	0.65	2.50	1.16
208	April 11, '10	106	14.37	85.63	8,158	13.94	0.69	2.47	1.32
225	May 12, '10	87	15.06	84.94	7,883	13.78	0.81	2.37	1.14
229	June 2, '10	87	14.80	85.20	8,114	12.53	1.07	2.70	1.35

Duplicate Samples: 23-24, 51-52, 55-56, and 71-72.

TABLE NO. 108.

RESULTS OF ANALYSES OF COMPOSITE GARBAGE SAMPLES.

Cincinnati.

(Results Calculated on Dry Basis.)

Sample Number.	Date of Collection.	No. of Loads Included.	Percentages.		Calorific Value B. T. U.	Percentages.			
			Ash.	Combustible Matter.		Ether Extract.	Phosphoric Acid as P_2O_5.	Nitrogen Kjeldahl Method.	Potash as K_2O.
91	September 9, '09	93	14.62	85.38	8,557	15.55	1.50	2.82	1.11
101	October 7, '09	101	12.71	87.29	8,828	18.06	1.38	2.87	1.27
111	November 5, '09	58	13.77	86.23	9,187	22.64	1.01	2.53	1.24
134	December 8, '09	34	16.14	83.86	8,372	14.52	1.04	2.59	1.04
148	January 7, '10	44	15.30	84.70	8,519	16.20	1.12	2.63	1.23
169	February 8, '10	48	16.91	83.09	8,312	16.98	1.91	2.70	1.20
187	March 8, '10	60	15.16	84.84	8,591	17.31	1.46	2.65	0.55
200	April 7, '10	64	15.41	84.59	8,375	16.37	1.40	2.82	1.21
216	May 3, '10	50	16.17	83.83	8,532	17.48	1.02	2.83	1.34
232	June 6, '10	67	20.35	79.66	8,272	16.41	0.71	2.92	1.32

TABLE NO. 109.

RESULTS OF ANALYSES OF COMPOSITE GARBAGE SAMPLES.

Columbus.

(Results Calculated on Dry Basis.)

Sample Number.	Date of Collection.	No. of Loads Included.	Percentages.		Calorific Value B. T. U.	Percentages.			
			Ash.	Combustible Matter.		Ether Extract.	Phosphoric Acid as P_2O_5.	Nitrogen Kjeldahl Method.	Potash as K_2O.
27	May 17, '09	38	15.11	4.89	8,311	19.15	0.79	2.50	0.93
28	May 17, '09	38	15.58	84.42	8,348	18.96	1.04	2.46	0.95
40	June 1, '09	41	14.64	85.36	8,498	17.68	0.71	2.40	1.23
41	June 1, '09	41	15.05	84.95	8,298	16.58	0.65	2.55	1.27
42	June 2, '09	36	15.44	84.56	8,269	16.25	0.77	2.93	1.25
43	June 3, '09	40	15.75	84.25	8,268	17.56	1.66	2.66	1.37
44	June 3, '09	40	16.15	83.85	8,051	16.88	0.89	2.52	1.28
45	June 4, '09	35	14.45	85.55	8,420	17.10	1.51	2.65	1.30
46	June 5, '09	30	15.00	85.00	8,326	18.86	1.34	2.65	1.13
47	June 5, '09	30	13.73	86.27	8,942	24.21	0.86	2.64	1.18
59	July 6, '09	45	15.88	84.12	8,352	17.74	0.98	2.48	1.28
60	July 6, '09	45	16.28	83.72	8,320	17.86	0.64	2.35	1.37
80	August 3, '09	49	14.14	85.86	8,418	16.45	1.01	2.40	1.22
81	August 3, '09	49	15.90	84.10	8,115	15.83	2.32	2.19	1.19
90	September 7, '09	58	12.24	87.76	8,520	14.85	0.73	2.62	1.13
100	October 4, '09	48	13.83	86.17	8,315	15.14	1.05	2.64	0.78
110	November 1, '09	43	13.05	86.95	8,370	16.34	0.91	2.33	1.08
124	November 29, '09	51	13.15	86.85	8,519	15.21	1.06	2.59	0.84
125	November 30, '09	41	13.57	86.43	8,455	16.45	1.61	2.57	0.85
126	November 30, '09	41	12.82	87.18	8,480	16.24	1.32	2.52	1.02
127	December 1, '09	51	14.93	85.07	8,457	16.88	1.34	2.55	0.92
128	December 2, '09	47	13.12	86.88	8,555	16.06	1.16	2.28	1.08
129	December 3, '09	38	14.88	85.12	8,325	15.77	1.32	2.53	1.08
130	December 3, '09	38	14.55	85.45	8,330	15.56	0.89	2.72	1.26
131	December 4, '09	38	14.08	85.92	8,818	16.95	1.47	2.70	1.19
147	January 4, '10	44	10.74	89.26	8,839	17.42	0.87	2.23	1.03
163	January 31, '10	38	10.96	89.04	8,824	17.92	0.71	2.39	1.08
185	February 25, '10	30	10.26	89.44	8,704	17.41	0.41	2.25	0.99
198	April 4, '10	41	17.66	82.34	8,195	16.06	0.89	2.60	0.89
220	May 6, '10	42	15.33	84.67	8,350	14.53	0.92	2.57	1.34
227	May 28, '10	34	15.94	84.06	8,316	17.51	1.07	2.93	0.99

Duplicate Samples: 27-28, 40-41, 43-44, 46-47, 59-60, 80-81, 125-126, and 129-130.

TABLE NO. 110.

RESULTS OF ANALYSES OF COMPOSITE GARBAGE SAMPLES.

Dayton.

(Results Calculated on Dry Basis.)

Sample Number.	Date of Collection.	No. of Loads Included.	Percentages.		Calorific Value B. T. U.	Percentages.			
			Ash.	Combustible Matter.		Ether Extract.	Phosphoric Acid as P_2O_5.	Nitrogen Kjeldahl Method.	Potash as K_2O.
32	May 21, '09	15	15.77	84.23	8,642	21.34	1.16	2.65	0.98
33	May 21, '09	15	13.75	86.25	8,797	20.77	1.05	2.56	1.88
48	June 8, '09	21	12.89	87.11	9,204	25.29	1.17	2.79	0.99
49	June 8, '09	21	14.21	85.79	9,228	23.38	1.07	2.60	1.25
62	July 12, '09	26	13.38	86.62	8,699	18.93	0.92	2.53	0.91
63	July 12, '09	26	12.41	87.59	8,942	22.50	1.16	2.58	0.98
64	July 13, '09	23	14.41	85.59	8,653	19.41	1.01	2.66	1.45
65	July 14, '09	24	14.25	85.75	8,467	18.90	1.13	2.78	1.21
66	July 14, '09	24	15.15	84.85	8,267	19.03	1.07	2.58	1.21
67	July 15, '09	20	13.89	86.11	8,463	18.54	0.87	2.40	1.20
68	July 16, '09	23	12.93	87.07	8,755	20.34	1.52	2.55	1.20
69	July 16, '09	23	15.73	84.27	8,435	19.75	1.22	2.68	1.19
70	July 17, '09	21	14.73	85.27	8,301	17.73	0.94	2.46	1.22
82	August 17, '09	25	11.55	88.45	8,949	18.33	0.97	2.40	1.08
83	August 17, '09	25	11.44	88.56	8,907	18.52	0.97	2.20	0.92
92	September 13, '09	22	12.49	87.51	8,858	20.32	0.94	2.74	1.20
104	October 20, '09	20	11.76	88.24	8,901	18.32	0.95	2.75	1.12
105	October 20, '09	20	11.62	88.38	8,918	17.38	0.98	2.68	1.17
114	November 11, '09	20	12.71	87.29	8,909	19.80	1.03	2.72	1.24
135	December 8, '09	18	12.40	87.60	8,918	20.00	1.42	2.96	0.73
149	January 10, '10	18	15.60	84.40	8,873	20.26	1.04	2.56	0.76
151	January 11, '10	18	10.50	89.50	8,703	18.10	0.93	2.61	0.86
153	January 12, '10	18	10.41	89.59	9,040	20.17	0.89	2.47	0.78
157	January 13, '10	16	11.18	88.82	8,957	20.00	0.60	2.46	0.72
160	January 14, '10	18	12.03	87.97	9,062	19.36	0.73	2.61	0.85
175	February 15, '10	18	13.02	86.98	8,179	21.10	0.89	2.63	0.80
190	March 8, '10	18	13.58	86.42	8,721	19.93	1.32	2.51	0.68
212	April 26, '10	19	13.90	86.10	8,846	20.83	0.90	2.77	1.05
222	May 10, '10	22	12.88	87.12	8,893	17.88	0.76	2.73	1.07
237	June 10, '10	20	16.15	83.85	8,292	16.15	0.72	2.60	1.00

Duplicate Samples: 32-33, 48-49, 62-63, 65-66, 68-69, 82-83, and 104-105.

TABLE NO. 111.

RESULTS OF ANALYSES OF COMPOSITE GARBAGE SAMPLES.

Canton, Mansfield, Marion, Steubenville and Zanesville.

Sample Number.	City.	Date of Collection.	Percentages.			Calorific Value B. T. U.	Percentages.			
			Moisture.	Ash.	Combustible Matter.		Ether Extract.	Phosphoric Acid as P_2O_5.	Nitrogen Kjeldahl Method.	Potash as K_2O.
73–74	Canton	7/29/09	75.4	2.80	21.80	2,236	5.47	0.34	0.64	0.28
75	Canton	7/30/09	77.3	3.10	19.60	1,971	4.75	0.36	0.60	0.28
164	Canton	2/1 /10	73.1	2.59	24.31	2,454	5.15	0.21	0.62	0.25
165	Canton	2/3 /10	72.8	2.47	24.73	2,489	5.38	0.18	0.65	0.27
85	Zanesville	8/26/09	83.5	2.27	14.23	1,331	1.74	0.15	0.30	0.25
86	Zanesville	8/27/09	84.0	1.66	14.34	1,305	1.64	0.09	0.29	0.27
297	Zanesville	4/21–22/10	79.4	3.49	17.11	1,612	2.45	0.14	0.46	0.31
94	Steubenville	9/22/09	75.5	3.59	20.91	2,100	4.15	0.20	0.57	0.27
95	Steubenville	9/23/09	76.6	2.85	20.55	1,990	2.73	0.14	0.54	0.29
103	Marion	10/28/09	79.6	2.72	17.68	1,809	4.28	0.14	0.49	0.23
107	Marion	10/29/09	77.3	3.18	19.52	2,042	4.74	0.22	0.65	0.23
117	Mansfield	11/18/09	77.4	3.19	19.41	1,902	3.89	0.21	0.86	0.30
118	Mansfield	11/19/09	77.9	3.10	19.00	1,761	2.96	0.14	0.98	0.29

TABLE NO. 112.

MONTHLY VARIATION IN COMPOSITION OF GARBAGE.

Cleveland.

(Averages of Analyses of Composite Samples.)

Month	No. of Samples Included.	Average Weight per Cubic Yard.	Percentages.			Calorific Value B. T. U.	Percentages.			
			Moisture.	Ash.	Combustible Matter.		Ether Extract.	Phosphoric Acid as P_2O_5.	Nitrogen Kjeldahl Method.	Potash as K_2O.
May, '09	2	1,322	72.7	3.50	23.84	2,262	4.54	0.32	0.73	0.35
June, '09	8	1,415	75.9	3.25	20.80	2,056	4.44	0.25	0.65	0.31
July, '09	2	1,371	76.4	3.19	20.50	2,059	4.89	0.28	0.64	0.26
August, '09	1	1,234	78.4	2.64	18.96	1,881	3.88	0.19	0.53	0.29
September, '09	1	1,106	78.0	2.84	18.26	1,808	3.46	0.20	0.56	0.31
October, '09	1	1,412	75.6	2.96	21.44	2,070	3.60	0.34	0.65	0.28
November, '09	1	1,482	76.7	3.00	20.30	2,024	4.04	0.23	0.63	0.30
December, '09	6	1,290	75.2	3.18	21.64	2,105	3.68	0.26	0.63	0.28
January, '10	1	1,194	76.1	3.00	20.90	2,086	3.80	0.23	0.68	0.25
February, '10	1	1,065	75.9	2.63	21.47	2,110	3.59	0.25	0.64	0.26
March, 10	1	1,428	72.7	3.58	23.72	2,264	3.78	0.18	0.68	0.32
April, '10	1	1,374	74.3	3.69	22.01	2,095	3.58	0.18	0.63	0.34
May, '10	1	1,415	73.3	4.02	22.68	2,105	3.68	0.22	0.63	0.30
June, '10	1	1,588	76.9	3.42	19.68	1,874	2.89	0.25	0.62	0.31
Average		1,333	75.6	3.20	21.16	2,057	3.85	0.24	0.64	0.30
Maximum		1,588	78.9	4.02	23.84	2,264	4.54	0.34	0.73	0.35
Minimum		1,065	72.7	2.63	18.26	1,808	2.89	0.18	0.53	0.25

TABLE NO. 113.

MONTHLY VARIATION IN COMPOSITION OF GARBAGE.

Cincinnati.

(Analyses of Composite Samples.)

Month	No. of Samples Included.	Average Weight per Cubic Yard.	Percentages. Moisture.	Ash.	Combustible Matter.	Calorific Value B. T. U.	Percentages. Ether Extract.	Phosphoric Acid as P_2O_5.	Nitrogen Kjeldahl Method.	Potash as K_2O.
September, '09	1	1,493	79.3	3.03	17.67	1,771	3.22	0.31	0.58	0.23
October, '09	1	1,205	76.3	3.01	20.69	2,092	4.28	0.33	0.68	0.30
November, '09	1	1,212	75.9	3.32	20.78	2,215	5.46	0.24	0.61	0.30
December, '09	1	1,153	77.4	3.65	18.95	1,892	3.28	0.23	0.58	0.23
January, '10	1	1,167	78.3	3.32	18.38	1,849	3.51	0.24	0.57	0.27
February, '10	1	1,102	76.8	3.92	19.28	1,935	3.94	0.44	0.63	0.26
March, '10	1	1,292	75.6	3.70	20.70	2,096	4.22	0.36	0.65	0.21
April, '10	1	1,230	75.9	3.71	20.39	2,018	3.94	0.34	0.68	0.29
May, '10	1	1,198	74.5	4.12	21.38	2,176	4.46	0.26	0.72	0.34
June, '10	1	1,223	76.4	4.80	18.80	1,952	3.87	0.17	0.69	0.31
Average		1,227	76.6	3.66	19.70	2,000	4.02	0.29	0.64	0.28
Maximum		1,493	79.3	4.80	20.78	2,215	5.46	0.36	0.72	0.34
Minimum		1,102	74.5	3.01	17.67	1,771	3.22	0.17	0.57	0.21

TABLE NO. 114.

MONTHLY VARIATION IN COMPOSITION OF GARBAGE.

Columbus.

(Averages of Analyses of Composite Samples.)

Month	No. of Samples Included.	Average Weight per Cubic Yard.	Percentages. Moisture.	Ash.	Combustible Matter.	Calorific Value B. T. U.	Percentages. Ether Extract.	Phosphoric Acid as P_2O_5.	Nitrogen Kjeldahl Method.	Potash as K_2O.
May, '09	2	1,177	73.2	4.09	22.61	2,237	5.12	0.25	0.67	0.25
June, '09	8	1,308	77.5	3.39	19.17	1,891	4.05	0.21	0.60	0.28
July, '09	2	1,316	77.9	3.56	18.55	1,842	3.93	0.18	0.54	0.29
August, '09	2	1,296	79.7	3.05	17.26	1,679	3.26	0.32	0.47	0.25
September, '09	1	1,216	79.6	2.50	17.90	1,738	3.03	0.15	0.53	0.23
October, '09	1	1,232	77.3	3.14	19.56	1,894	3.44	0.24	0.60	0.18
November, '09	1	1,289	76.3	3.09	20.61	1,984	3.87	0.22	0.55	0.26
December, '09	8	1,221	75.7	3.39	21.07	2,065	3.96	0.32	0.62	0.25
January, '10	1	1,022	74.1	2.78	23.12	2,289	4.51	0.23	0.58	0.27
February, '10	1	1,072	76.3	2.60	21.10	2,091	4.25	0.17	0.57	0.26
March, '10	1	813	76.8	2.43	20.57	2,019	4.00	0.09	0.52	0.23
April, '10	1	1,222	73.9	4.61	21.49	2,139	4.19	0.23	0.68	0.23
May, '10	1	1,120	76.2	3.65	20.15	1,987	3.46	0.22	0.61	0.32
June, '10	1	1,213	75.4	3.92	20.68	2,046	4.31	0.26	0.72	0.24
Average		1,173	76.4	3.30	20.27	1,994	3.96	0.22	0.59	0.25
Maximum		1,316	79.7	4.61	23.12	2,289	5.12	0.32	0.72	0.32
Minimum		813	73.2	2.43	17.26	1,679	3.03	0.09	0.47	0.18

TABLE NO. 115.

MONTHLY VARIATION IN COMPOSITION OF GARBAGE.

Dayton.

(Averages of Analyses of Composite Samples.)

Month	No. of Samples Included.	Average weight per Cubic Yard.	Percentages. Moisture.	Ash.	Combustible Matter.	Calorific value B. T. U.	Percentages. Ether Extract.	Phosphoric Acid as P_2O_5.	Nitrogen Kjeldahl Method.	Potash as K_2O.
May, '09	2	1,639	79.8	2.98	17.22	1,762	4.26	0.22	0.53	0.29
June, '09	2	1,512	80.5	2.64	16.86	1,797	4.76	0.22	0.53	0.21
July, '09	9	1,524	82.6	2.46	14.96	1,490	3.37	0.19	0.45	0.21
August, '09	2	.....	82.2	2.05	15.80	1,593	3.29	0.17	0.41	0.18
September, '09	1	1,596	82.2	2.22	15.58	1,577	3.62	0.17	0.49	0.21
October, '09	2	1,642	83.3	1.96	14.74	1,488	2.98	0.16	0.46	0.19
November, '09	1	1,536	82.5	2.22	15.28	1,559	3.47	0.18	0.48	0.22
December, '09	1	1,296	81.7	2.27	16.03	1,682	3.66	0.26	0.54	0.18
January, '10	5	1,259	79.9	2.42	17.68	1,795	3.93	0.17	0.51	0.16
February, '10	1	1,154	79.7	2.64	17.66	1,823	4.28	0.18	0.53	0.16
March, '10	1	1,523	77.9	2.99	19.01	1,927	4.38	0.29	0.55	0.15
April, '10	1	1,538	78.2	3.03	18.77	1,928	4.54	0.17	0.60	0.23
May, '10	1	1,551	79.1	2.69	18.21	1,859	3.74	0.16	0.57	0.22
June, '10	1	1,490	79.0	3.39	17.61	1,741	3.39	0.15	0.55	0.21
Average	.....	1,481	80.6	2.57	16.82	1,712	3.88	.19	.51	.20
Maximum	.....	1,612	83.3	3.39	19.01	1,927	4.76	.29	.60	.29
Minimum	.....	1,154	78.2	1.96	14.74	1,488	2.98	.15	.41	.18

TABLE NO. 116.

MONTHLY VARIATION IN COMPOSITION OF GARBAGE.

Cleveland.

(Averages of Analyses of Composite Samples. Results Calculated on Dry Basis.)

Month.	No. of Samples Included.	Percentages. Ash.	Combustible Matter.	Calorific value B. T. U.	Percentages. Ether Extract.	Phosphoric Acid as P_2O_5.	Nitrogen Kjeldahl Method.	Potash as K_2O.
May, '09	2	12.82	87.18	8,272	16.61	1.18	2.65	1.26
June, '09	8	13.53	86.47	8,548	18.45	1.63	2.71	1.31
July, '09	2	13.11	86.89	8,727	20.72	1.16	2.72	1.11
August, '09	1	12.23	87.77	8,721	17.06	0.87	2.46	1.34
September, '09	1	13.48	86.52	8,569	16.39	0.96	2.65	1.49
October, '09	1	12.13	87.87	8,486	14.77	1.38	2.67	1.15
November, '09	1	12.86	87.14	8,655	17.31	0.99	2.69	1.28
November, '09	6	12.81	87.19	8,488	14.84	1.02	2.53	1.12
January, '10	1	12.55	87.45	8,728	15.90	0.97	2.84	1.06
February, '10	1	10.90	89.10	8,755	11.89	1.05	2.64	1.10
March, '10	1	13.10	86.90	8,294	13.84	0.65	2.50	1.16
April, '10	1	14.37	85.63	8,153	13.94	0.69	2.47	1.32
May, '10	1	15.06	84.94	7,883	13.78	0.81	2.37	1.14
June, '10	1	14.80	85.20	8,114	12.53	1.07	2.70	1.35
Average	.....	13.12	86.88	8,459	15.85	0.99	2.61	1.23
Maximum	.....	15.06	89.10	8,755	20.72	1.38	2.84	1.49
Minimum	.....	10.90	84.94	7,883	12.53	0.65	2.37	1.06

TABLE NO. 117.

MONTHLY VARIATION IN COMPOSITION OF GARBAGE.

Cincinnati.

(Analyses of Composite Samples. Results Calculated on Dry Basis.)

Month.	No. of Samples Included.	Percentages.		Calorific value B. T. U.	Percentages.			
		Ash.	Combustible Matter.		Ether Extract.	Phosphoric Acid as P_2O_5.	Nitrogen Kjeldahl Method.	Potash as K_2O.
September, '09	1	14.62	85.38	8,557	15.55	1.59	2.82	1.11
October, '09	1	12.71	87.29	8,828	18.06	1.38	2.87	1.27
November, '09	1	13.77	86.23	9,187	22.64	1.01	2.53	1.24
December, '09	1	16.14	83.86	8,372	14.52	1.04	2.59	1.04
January, '10	1	15.30	84.70	8,519	16.20	1.12	2.63	1.23
February, '10	1	16.91	83.09	8,342	16.98	1.91	2.70	1.20
March, '10	1	15.16	84.84	8,592	17.31	1.46	2.65	0.88
April, '10	1	15.41	84.59	8,375	16.37	1.40	2.82	1.21
May, '10	1	16.17	83.83	8,532	17.48	1.02	2.83	1.34
June, '10	1	20.35	79.66	8,272	16.41	0.71	2.92	1.32
Average		15.65	84.35	8,558	17.15	1.26	2.74	1.18
Maximum		20.35	87.29	9,187	22.64	1.91	2.92	1.34
Minimum		12.71	79.66	8,272	14.52	0.71	2.53	0.88

TABLE NO. 118.

MONTHLY VARIATION IN COMPOSITION OF GARBAGE.

Columbus.

(Averages of Analyses of Composite Samples. Results Calculated on Dry Basis.)

Month.	No. of Samples Included.	Percentages.		Calorific value B. T. U.	Percentages.			
		Ash.	Combustible Matter.		Ether Extract.	Phosphoric Acid as P_2O_5.	Nitrogen Kjeldahl Method.	Potash as K_2O.
May, '09	2	15.35	84.65	8,330	19.06	0.92	2.48	0.94
June, '09	8	15.03	84.97	8,388	18.14	1.05	2.62	1.25
July, '09	2	16.08	83.92	8,337	17.80	0.81	2.42	1.33
August, '09	2	15.02	84.98	8,207	16.07	1.63	2.30	1.21
September, '09	1	12.24	87.76	8,520	14.85	0.73	2.62	1.13
October, '09	1	13.83	86.17	8,315	15.14	1.05	2.64	0.78
November, '09	1	13.05	86.95	8,370	16.34	0.91	2.33	1.06
December, '09	8	13.89	86.11	8,492	16.14	1.27	2.56	1.03
January, '10	1	10.74	89.26	8,839	17.42	0.87	2.23	1.03
February, '10	1	10.96	89.04	8,824	17.92	0.71	2.39	1.03
May, '10	1	10.56	89.44	8,704	17.41	0.41	2.25	0.99
April, '10	1	17.66	82.34	8,195	16.06	0.89	2.60	0.89
May, '10	1	15.33	84.67	8,350	14.53	0.92	2.57	1.34
June, '10	1	15.94	84.06	8,316	17.51	1.07	2.93	0.99
Average		13.98	86.02	8,448	16.74	0.95	2.59	1.06
Maximum		17.66	89.44	8,839	19.06	1.63	2.93	1.34
Minimum		10.56	82.34	8,195	14.53	0.41	2.23	0.78

TABLE NO. 119.

MONTHLY VARIATION IN COMPOSITION OF GARBAGE.

Dayton.

(Averages of Analyses of Composite Samples. Results Calculated on Dry Basis.)

Month.	No. of Samples Included.	Percentages.		Calorific value B. T. U.	Percentages.			
		Ash.	Combustible Matter.		Ether Extract.	Phosphoric Acid as P_2O_5.	Nitrogen Kjeldahl Method.	Potash as K_2O.
May, '09	2	14.76	85.24	8,719	21.06	1.11	2.61	1.42
June, '09	2	13.55	86.45	9,216	24.41	1.12	2.70	1.10
July, '09	9	14.10	85.90	8,554	19.46	1.09	2.58	1.17
August, '09	2	11.50	88.50	8,928	18.44	0.97	2.30	1.00
September, '09	1	12.49	87.51	8,858	20.22	0.94	2.74	1.20
October, '09	2	11.69	88.31	8,909	17.85	0.97	2.73	1.15
November, '09	1	12.71	87.29	8,909	19.80	1.08	2.72	1.24
December, '09	1	12.40	87.60	8,918	20.00	1.42	2.96	0.78
January, '10	5	11.94	88.06	8,927	19.58	0.84	2.55	0.79
February, '10	1	13.02	86.98	8,179	21.10	0.89	2.68	0.80
March, '10	1	13.58	86.42	8,721	19.93	1.32	2.51	0.68
April, '10	1	13.90	86.10	8,846	20.88	0.80	2.77	1.05
May, '10	1	12.88	87.12	8,893	17.88	0.76	2.73	1.07
June, '10	1	16.15	83.85	8,292	16.15	0.72	2.60	1.00
Average	.....	13.19	86.81	8,776	19.77	1.00	2.65	1.08
Maximum	.....	16.15	88.50	8,928	24.41	1.42	2.96	1.42
Minimum	.....	11.50	83.85	8,179	16.15	.72	2.30	0.68

TABLE NO. 120.

DAILY VARIATION IN COMPOSITION OF GARBAGE.

Cleveland.

June 15 to June 21, 1909, and Dec. 15 to Dec. 18, 1909.

Day of Collection.	No. of Loads Included.	Average Weight per Cubic Yard.	Percentages.			Calorific Value B. T. U.	Percentages.			
			Moisture.	Ash.	Combustible Matter.		Ether Extract.	Phosphoric Acid as P_2O_5.	Nitrogen Kjeldahl Method.	Potash as K_2O.
June 15—Tuesday	89	1,519	75.7	3.61	20.74	2,014	4.25	0.29	0.65	0.31
June 16—Wednesday	82	1,428	76.8	3.19	20.01	1,966	3.89	0.19	0.62	0.31
June 17—Thursday*	21	1,420	74.6	3.08	22.32	2,238	5.12	0.30	0.83	0.30
June 18—Friday	88	1,545	77.0	2.87	20.18	2,018	4.50	0.21	0.61	0.36
June 19—Saturday	84	1,366	75.7	3.01	21.29	2,106	4.70	0.21	0.60	0.29
June 21—Monday	90	1,439	75.2	3.82	20.98	2,076	4.38	0.31	0.66	0.29
December 13—Monday	104	1,502	76.0	3.07	20.98	2,047	3.47	0.26	0.61	0.19
December 14—Tuesday	98	1,467	74.2	3.80	22.00	2,177	4.30	0.32	0.64	0.23
December 15—Wednesday	91	1,375	75.7	3.26	21.14	2,048	3.54	.....	0.58	0.28
December 16—Thursday	89	1,290	75.2	2.86	21.94	2,119	3.71	0.26	0.65	0.28
December 17—Friday	92	1,158	75.0	3.12	21.88	2,146	3.72	0.25	0.63	0.31
December 18—Saturday	74	960	75.1	2.97	21.93	2,094	3.37	0.19	0.65	0.33

* Sampling stopped at noon. Morning loads include all hotel garbage.

TABLE NO. 121.

DAILY VARIATION IN COMPOSITION OF GARBAGE.

Columbus.

June 1 to June 5, 1909, and Nov. 29 to Dec. 4, 1909.

Day of Collection.	No. of Loads Included.	Average Weight per Cubic Yard.	Percentages.			Calorific Value B. T. U.	Percentages.			
			Moisture.	Ash.	Combustible Matter.		Ether Extract.	Phosphoric Acid as P_2O_5.	Nitrogen Kjeldahl Method.	Potash as K_2O.
June 1—Tuesday	41	1,302	77.4	3.85	19.25	1,903	3.89	0.16	0.56	0.29
June 2—Wednesday	36	1,284	77.5	3.47	19.03	1,861	3.66	0.17	0.66	0.28
June 3—Thursday	40	1,302	78.0	3.52	18.58	1,799	3.80	0.28	0.57	0.30
June 4—Friday	35	1,311	77.1	3.31	19.59	1,928	3.92	0.35	0.61	0.30
June 5—Saturday	30	1,342	77.3	3.31	19.44	1,966	4.98	0.25	0.60	0.27
November 29—Monday	51	1,296	75.7	3.20	21.10	2,070	3.70	0.26	0.63	0.30
November 30—Tuesday	41	1,251	74.7	3.35	22.00	2,147	4.15	0.37	0.65	0.24
December 1—Wednesday	51	1,227	74.3	3.84	21.86	2,174	4.34	0.34	0.66	0.24
December 2—Thursday	47	1,221	74.9	3.29	21.81	2,147	4.03	0.29	0.57	0.27
December 3—Friday	38	1,252	77.0	3.38	19.62	1,915	3.60	0.25	0.60	0.27
December 4—Saturday	38	1,202	76.7	3.28	20.02	2,055	3.96	0.34	0.63	0.28

TABLE NO. 122.

DAILY VARIATION IN COMPOSITION OF GARBAGE.

Dayton.

July 12 to July 17, 1909, and Jan. 8 to Jan. 14, 1910.

Day of Collection.	No. of Loads Included.	Average Weight per Cubic Yard.	Percentages.			Calorific Value B. T. U.	Percentages.			
			Moisture.	Ash.	Combustible Matter.		Ether Extract.	Phosphoric Acid as P_2O_5.	Nitrogen Kjeldahl Method.	Potash as K_2O.
July 12—Monday	26	1,590	80.15	2.56	17.30	1,748	4.14	0.21	0.51	0.19
July 13—Tuesday	23	1,530	82.9	2.46	14.64	1,480	3.32	0.17	0.45	0.25
July 14—Wednesday	24	1,500	83.4	2.44	14.16	1,389	3.15	0.19	0.45	0.20
July 15—Thursday	20	1,437	83.6	2.27	14.13	1,386	3.04	0.14	0.39	0.20
July 16—Friday	23	1,558	82.1	2.58	15.37	1,542	3.60	0.25	0.47	0.22
July 17—Saturday	21	1,527	83.4	2.43	14.17	1,378	2.95	0.16	0.41	0.20
January 8—Saturday*	18	.....	83.3	2.02	14.68	1,493	3.58	0.29	0.49	0.12
January 10—Monday	18	1,051	77.6	3.49	18.91	1,988	4.51	0.24	0.57	0.17
January 11—Tuesday	18	**970	79.2	2.18	18.62	1,810	3.76	0.19	0.54	0.18
January 12 Wednesday	18	1,169	8.00	2.08	17.92	1,808	4.03	0.18	0.49	0.16
January 13—Thursday	16	1,258	81.1	2.11	16.79	1,693	3.78	0.11	0.46	0.14
January 14—Friday	18	1,346	81.5	2.23	16.27	1,676	3.58	0.14	0.49	0.16

* Saturday sample from beater.
** Garbage frozen.

TABLE NO. 123.

DAILY VARIATION IN COMPOSITION OF GARBAGE.

Cleveland.

June 15 to June 21, 1909, and Dec. 13 to Dec. 18, 1909.

(Results Calculated on Dry Basis.)

Day of Collection.	No. of Loads Included.	Percentages.		Calorific Value B. T. U.	Percentages.			
		Ash.	Combustible Matter.		Ether Extract.	Phosphoric Acid as P_2O_5.	Nitrogen Kjeldahl Method.	Potash as K_2O.
June 15—Tuesday	89	14.82	85.18	8,278	17.46	1.17	2.67	1.25
June 16—Wednesday	82	13.73	86.27	8,475	16.77	0.81	2.68	1.32
June 17—Thursday*	21	12.14	87.86	8,813	20.16	1.13	2.27	1.39
June 18—Friday	86	12.46	87.54	8,754	19.51	0.89	2.64	1.54
June 19—Saturday	84	12.40	87.60	8,666	19.34	0.88	2.45	1.30
June 21—Monday	90	15.42	84.58	8,372	17.45	1.24	2.66	1.19
December 13—Monday	104	12.80	87.20	8,580	14.47	1.07	2.55	0.81
December 14—Tuesday	98	14.72	85.28	8,436	16.65	1.24	2.50	0.91
December 15—Wednesday	91	13.36	86.64	8,428	14.52	.....	2.40	1.17
December 16—Thursday	89	11.54	88.46	8,544	14.98	1.04	2.61	1.14
December 17—Friday	92	12.48	87.52	8,583	14.88	0.99	2.53	1.27
December 18—Saturday	74	11.94	88.06	8,408	13.52	0.77	2.61	1.31

* Sampling stopped at noon. Morning loads include all hotel garbage.

TABLE NO. 124.

DAILY VARIATION IN COMPOSITION OF GARBAGE.

Columbus.

June 1 to June 5, 1909, and Nov. 29 to Dec. 4, 1909.

(Results Calculated on Dry Basis.)

Day of Collection.	No. of Loads Included.	Percentages.		Calorific Value B. T. U.	Percentages.			
		Ash.	Combustible Matter.		Ether Extract.	Phosphoric Acid as P_2O_5.	Nitrogen Kjeldahl Method.	Potash as K_2O.
June 1—Tuesday	41	14.85	85.15	8,398	17.13	0.68	2.48	1.25
June 2—Wednesday	36	15.44	84.56	8,269	16.25	0.77	2.93	1.25
June 3—Thursday	40	15.95	84.05	8,157	17.19	1.28	2.59	1.33
June 4—Friday	35	14.45	85.55	8,420	17.10	1.51	2.65	1.30
June 5—Saturday	30	14.36	85.64	8,634	21.56	1.10	2.65	1.16
November 29—Monday	51	13.15	86.85	8,519	15.21	1.06	2.59	0.84
November 30—Tuesday	41	13.20	86.80	8,468	16.35	1.47	2.55	0.94
December 1—Wednesday	51	14.93	85.07	8,457	16.88	1.34	2.55	0.92
December 2—Thursday	47	13.12	86.88	8,555	16.06	1.16	2.28	1.08
December 3—Friday	38	14.72	85.28	8,328	15.67	1.11	2.63	1.17
December 4—Saturday	38	14.08	85.92	8,818	16.95	1.47	2.70	1.19

TABLE NO. 125.

DAILY VARIATION IN COMPOSITION OF GARBAGE.

Dayton.

July 12 to July 17, 1909, and Jan. 8 to Jan. 14, 1910.

(Results Calculated on Dry Basis.)

Day of Collection.	No. of Loads Included.	Percentages.		Calorific Value B. T. U.	Percentages.			
		Ash.	Combustible Matter.		Ether Extract.	Phosphoric Acid as P_2O_5.	Nitrogen Kjeldahl Method.	Potash as K_2O.
July 12—Monday	26	12.89	87.11	8,821	20.71	1.04	2.56	0.95
July 13—Tuesday	23	14.41	85.59	8,663	19.41	1.01	2.66	1.45
July 14—Wednesday	24	14.70	85.30	8,367	18.97	1.10	2.68	1.21
July 15—Thursday	20	13.89	86.11	8,463	18.54	0.87	2.40	1.20
July 16—Friday	23	14.33	85.67	8,595	20.05	1.37	2.62	1.20
July 17—Saturday	21	14.73	85.27	8,301	17.73	0.94	2.46	1.22
January 8—Saturday	18	12.10	87.90	8,937	21.43	1.75	2.91	0.73
January 10—Monday	18	15.60	84.40	8,573	20.26	1.07	2.56	0.76
January 11—Tuesday	18	10.50	89.50	8,703	18.10	0.93	2.61	0.86
January 12—Wednesday	18	10.41	89.59	9,040	20.17	0.89	2.47	0.78
January 13—Thursday	16	11.18	88.82	8,957	20.00	0.60	2.46	0.72
January 14—Friday	18	12.03	87.97	9,062	19.36	0.73	2.64	0.85

TABLE NO. 126.

RESULTS OF ANALYSES OF SPECIAL SAMPLES OF GARBAGE.

Sample Number.	City.	Date of Collection.	No. of Loads Included.	Percentages.			Calorific Value B. T. U.	Percentages.			
				Moisture.	Ash.	Combustible Matter.		Ether Extract.	Phosphoric Acid as P_2O_5.	Nitrogen Kjeldahl Method.	Potash as K_2O.
19	Dayton	April 14, '09....	1	74.8	3.71	21.49	2,173	5.92	0.34	0.67	0.24
144	Cleveland	December 16, '09	8	75.0	2.32	22.68	2,209	4.24	0.22	0.65	0.33
20	Dayton	April 14, '09....	1	73.4	2.83	23.77	2,405	7.70	0.25	0.65	0.19
29	Columbus	May 17, '09.....	1	7.16	7.02	21.88	2,062	3.72	0.16	0.61	0.37
34	Dayton	May 21, '09.....	1	8.09	3.15	15.95	1,509	1.50	0.15	0.45	0.19
132	Columbus	December 4, '09.	5	75.2	3.95	20.85	2,098	4.08	0.37	0.60	0.26
142	Cleveland	December 15, '09	7	76.4	3.08	20.52	1,981	3.41	0.22	0.63	0.27
18	Dayton	April 14, '09.....	1	77.7	2.87	19.43	2,006	5.49	0.36	0.63	0.16
25	Cleveland	May 14, '09.....	2	74.1	2.31	23.59	2,289	5.20	0.40	0.97	0.23
186	Columbus	February 25, '10.	4	74.8	3.66	21.54	2,180	5.17	0.42	0.70	0.20

NOTES.

Samples Nos. 19 and 144: Garbage from high class residential districts.
Samples Nos. 20, 29, 34, 132 and 142: Garbage from low class residential districts.
Samples Nos. 18, 25 and 186: Garbage from restaurants and hotels.

TABLE NO. 127.

RESULTS OF ANALYSES OF COMPOSITE SAMPLES OF GARBAGE FROM BEATER.

Dayton.

Sample Number.	Date of Collection.	Percentages.			Calorific Value B. T. U.	Percentages.			
		Moisture.	Ash.	Combustible Matter.		Ether Extract.	Phosphoric Acid as P_2O_5.	Nitrogen Kjeldahl Method.	Potash as K_2O.
115	November 11, '09	78.9	3.02	18.08	1,859	4.22	0.37	0.65	0.22
136	December 8, '09	81.8	2.78	15.42	1,600	3.85	0.42	0.55	0.20
150	January 8, '10	83.3	2.02	14.68	1,498	3.58	0.29	0.49	0.12
152	January 10, '10	81.4	2.37	16.23	1,659	4.00	0.26	0.48	0.16
154	January 11, '10	83.3	2.04	14.66	1,490	3.58	0.27	0.46	0.12
155	January 12, '10	83.3	2.12	14.58	1,519	3.40	0.24	0.47	0.13
158	January 13, '10	83.5	2.00	14.50	1,478	3.26	0.26	0.45	0.13
176	February 15, '10	78.6	3.19	18.21	1,877	3.86	0.34	0.62	0.14
191	March 8, '10	78.8	3.27	17.93	1,903	4.41	0.33	0.62	0.16
213	April 26, '10	78.4	3.51	18.09	1,867	4.28	0.33	0.64	0.23
223	May 10, '10	77.4	3.59	19.01	1,990	4.61	0.33	0.68	0.21

NOTES.

Samples from beater are practically samples of raw garbage. The beater used was of the ordinary paper mill type and was employed at the Dayton plant to convert the raw material into a pulp-like mass, the process of digestion being omitted. The samples obtained from the beater are more representative of the garbage than the composite samples regularly collected as a much better mixture and incorporation of the various constituents was obtained before the portion for sampling was taken.

TABLE NO. 128.

RESULTS OF ANALYSES OF COMPOSITE SAMPLES OF GARBAGE FROM BEATER.

Dayton.

(Results Calculated on Dry Basis.)

Sample Number.	Date of Collection.	Percentages.		Calorific Value B. T. U.	Percentages.			
		Ash.	Combustible Matter.		Ether Extract.	Phosphoric Acid as P_2O_5.	Nitrogen Kjeldahl Method.	Potash as K^2O.
115	November 11, '09	14.31	85.69	8,812	19.98	1.77	3.06	1.02
136	December 8, '09	15.26	84.74	8,792	21.16	2.36	3.05	1.08
150	January 8, '10	12.10	87.90	8,937	21.43	1.75	2.91	0.73
152	January 10, '10	12.77	87.23	8,917	21.50	1.40	2.60	0.84
154	January 11, '10	12.21	87.79	8,923	21.15	1.63	2.74	0.72
155	January 12, '10	12.72	87.28	9,098	20.33	1.43	2.81	0.78
158	January 13, '10	12.10	87.90	8,958	19.75	1.55	2.71	0.78
176	February 15, '10	14.92	85.08	8,773	18.09	1.60	2.89	0.67
191	March 8, '10	15.41	84.59	8,976	20.82	1.54	2.91	0.74
213	April 26, '10	16.25	83.75	8,642	19.81	1.55	2.96	1.05
223	May 10, '10	15.90	84.10	8,807	20.42	1.48	2.80	0.94

APPENDIX IV.

COMPOSITION OF GARBAGE TANKAGE FROM REDUCTION PROCESS.

CLEVELAND.

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DAYTON.

TABLE NO. 129.

RESULTS OF ANALYSES OF TANKAGE FROM PROCESSES OF REDUCTION.

Cleveland.

Sample Number.	Date of Collection.	Percentages.			Calorific Value B. T. U.	Percentages.			
		Moisture.	Ash.	Combustible Matter.		Ether Extract.	Phos-horic Acid as P_2O_5.	Nitrogen Kjeldahl Method.	Potash as K_2O.
30	May 19, '09	17.25	25.61	57.14	4,272	1.49	3.78	3.12	0.54
31	May 19, '09	6.25	20.75	73.00	8,377	19.62	3.21	3.27	0.47
181	February 18-19, '09	2.05	23.48	74.47	8,435	20.69	3.84	2.43	0.41
182	February 18-19, '10	14.20	28.61	57.19	5,283	1.13	3.56	2.44	0.41
188	February 19, '10	14.30	26.28	59.42	5,660	0.76	3.85	2.32	0.37
230	June 2, '10	16.20	30.38	53.42	4,845	1.42	3.41	2.52	0.47
231	June 2, '10	3.92	27.10	68.98	7,529	15.98	3.15	2.61	0.44

NOTES.

Sample No.

30 Tankage from percolators. } Representing same material as Samples 23 and 24.
31 Tankage from dryers before percolation. }

181 Tankage from dryers before percolation. } Representing same material as sample 180.
182 Tankage from percolator. }
188 Tankage from percolator after screening. }

230 Tankage from percolator.
231 Tankage from dryers before percolation.

TABLE NO. 130.

RESULTS OF ANALYSES OF TANKAGE FROM PROCESSES OF REDUCTION.

Cincinnati.

Sample Number.	Date of Collection.	Percentages.			Calorific Value B. T. U.	Percentages.			
		Moisture.	Ash.	Combustible Matter.		Ether Extract.	Phosphoric Acid as P_2O_5.	Nitrogen Kjeldahl Method.	Potash as K_2O.
170	February 9, '10	37.90	23.93	38.17	4,190	3.29	3.15	1.97	0.10
171	February 9, '10	3.07	31.68	65.25	6,749	9.25	4.48	2.76	0.12
188	March 3, '10	2.69	29.31	68.00	7,477	10.42	4.37	2.98	0.16
201	April 7, '10	2.80	31.03	66.17	7,171	10.84	5.45	3.07	0.19
217	May 3, '10	2.73	33.35	63.92	6,868	9.81	5.73	2.93	0.21

NOTES.

Sample No.

170 Pressed garbage before drying; composite of day's run.
171 Dried tankage from screens; composite of week's storage.
188 Dried tankage from screens; composite of two weeks' storage.
201 Dried tankage from screens; composite of two weeks' storage.
217 Dried tankage from screens; composite of 10 days' storage.

TABLE NO. 131.

RESULTS OF ANALYSES OF TANKAGE FROM PROCESSES OF REDUCTION.

Dayton.

Sample Number.	Date of Collection.	Percentages.			Calorific Value B. T. U.	Percentages.			
		Moisture.	Ash.	Combustible Matter.		Ether Extract.	Phosphoric Acid as P_2O_5.	Nitrogen Kjeldahl Method.	Potash as K_2O.
22	April 20, '09	18.72	15.15	66.13	5,109	2.07	1.91	3.43	0.62
37	May 25, '09	19.65	14.74	65.61	5,549	3.84	2.37	3.25	1.14
193	March 8, '10	17.80	17.19	65.01	6,153	3.03	2.21	2.83	0.90
215	April 27, '10	20.00	17.38	62.62	5,796	4.29	1.53	2.54	0.96
240	June 11, '10	27.80	15.15	57.55	5,119	2.89	1.27	2.58	0.78
	Average	20.70	15.92	63.38	5,543	3.12	1.86	2.93	0.88
21	April 20, '09	14.52	12.76	72.72	7,609	16.47	1.59	2.93	0.73
36	May 25, '09	15.92	13.11	70.94	7,425	16.05	1.46	3.05	0.80
	Average	15.24	12.93	71.83	7,517	16.26	1.52	2.99	0.77
137	December 9, 10, '09	9.58	12.46	77.96	7,353	13.83	2.06	2.69	0.96
156	January 12, 13, '10	26.60	11.42	61.98	6,382	12.83	1.29	2.02	0.71
159	January 14, '10	13.50	12.27	74.23	7,673	15.53	1.23	2.37	0.79
177	February 15, 16, '10	11.10	15.55	73.35	7,570	15.92	1.72	2.63	0.76
192	March 8, 9, '10	9.32	16.18	74.50	7,779	15.27	1.66	2.57	1.01
214	April 26, 27, '10	10.70	17.59	71.71	7,515	13.66	1.79	2.64	1.15
224	May 10, 11, '10	10.50	14.56	74.94	7,547	15.02	1.48	2.62	0.96
238	June 11, '10	22.30	11.58	66.12	6,656	13.56	0.75	2.07	0.72
	Average	14.20	13.95	71.85	7,309	14.45	1.50	2.44	0.89

NOTES.

Samples 22, 37, 193, 215, 240: Dried, screened tankage.
Samples 21 and 36: Tankage from steam dryers before percolation.
Samples 137, 156, 159, 177, 192, 214, 226, and 238: Tankage from direct heat dryers before percolation.

APPENDIX V.

COMPOSITION OF RUBBISH AND ASHES.

MECHANICAL SEPARATION OF RUBBISH AND ASHES.

ANALYSES OF ASHES.

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DAYTON.

TABLE NO. 132.

RESULTS OF MECHANICAL SEPARATION OF RUBBISH AND ASHES.

Cleveland.

Date of Collection.	Number of loads.	Average Weight of Load.	Constituents in Percentages.												
			Paper.	Rags.	Wood.	Tins.	Iron.	Other Metal.	Whole Bottles. Weight.	Whole Bottles. Number.	Broken Glass and Crockery.	Leather.	Garbage. Bones.	Garbage. Other Garbage.	Ashes and Dirt.
5/15/09	1	3,400	5.3	1.9	0.7	2.8	.....	0.1	.....	.....	2.5	0.4	.....	.....	86.3
7/21/09	1	3,090	7.2	1.4	1.1	3.5	.....	.....	0.9	25	1.7	.....	0.3	.....	83.9
9/17/09	1	3,750	1.4	0.6	0.7	0.8	1.0	.....	0.7	49	1.0	0.4	0.4	1.4	91.6
11/9/09	2	2,363	3.2	1.1	4.2	5.0	0.8	0.2	1.8	72	3.1	0.6	.....	.....	80.0
1/20/10	1	2,707	2.9	0.8	3.8	0.9	0.1	.....	0.3	10	0.6	.....	0.2	0.2	90.2
3/11/10	1	2,540	11.5	0.9	1.8	3.3	.....	.....	0.7	29	7.9	0.1	.....	1.3	72.5
4/12/10	2	2,745	1.1	0.6	1.4	4.1	0.4	0.8	0.9	47	1.8	0.5	.....	0.1	88.3
6/1 /10	1	2,220	6.8	1.8	2.0	3.2	1.7	0.1	1.9	70	1.4	0.6	.....	0.3	80.2
Av'r'ge	....	2,792	4.9	1.1	2.0	2.9	0.5	0.2	0.9	38	2.5	0.3	0.1	0.4	84.1

TABLE NO. 133.

RESULTS OF MECHANICAL SEPARATION OF RUBBISH AND ASHES.

Cincinnati.

Date of Collection.	Number of Loads Included.	Average Weight of Load.	Constituents in Percentages.												
			Paper.	Rags.	Wood.	Tins.	Iron.	Other Metal.	Whole Bottles. Weight.	Whole Bottles. Number.	Broken Glass and Crockery.	Leather.	Garbage. Bones.	Garbage. Other Garbage.	Ashes and Dirt.
5/28/09	2	1,680	5.4	1.5	3.1	2.7	0.4	.....	0.7	15	1.3	0.1	0.4	0.6	83.8
6/11/09	1	2,320	15.2	1.8	0.8	2.5	0.9	.....	1.3	56	2.0	0.6	.....	0.9	74.0
6/12/09	2	1,688	14.2	2.8	0.7	2.6	1.8	.....	0.9	17	2.7	0.9	.....	2.0	71.4
7/9 /09	1	1,300	13.0	1.2	1.9	4.5	.....	.....	0.9	13	1.5	1.9	.....	.....	75.1
9/10/09	1	1,818	7.3	1.8	1.4	2.0	0.3	.....	0.6	12	1.7	0.4	.....	0.4	78.1
10/6/09	1	2,000	5.2	1.1	1.8	1.8	0.3	.....	1.4	24	3.3	0.3	0.1	0.3	84.4
11/4/09	1	2,000	10.0	0.7	1.0	2.2	0.5	.....	1.9	61	2.4	0.2	0.1	0.5	80.5
12/7/09	1	2,080	2.5	0.3	0.5	1.9	0.4	.....	0.7	20	1.7	0.1	.....	1.4	90.5
2/10/10	4	1,980	1.7	0.3	0.2	1.5	0.03	.....	0.3	10	0.5	0.1	0.03	0.2	95.1
3/4 /10	4	2,390	2.3	0.5	1.1	1.7	0.04	.....	0.6	17	0.9	0.1	0.1	0.5	92.2
4/8 /10	2	2,120	6.0	0.7	0.5	4.5	0.3	0.02	1.9	49	2.6	0.4	.....	0.07	83.0
5/4 /10	2	1,405	9.3	2.2	0.8	2.7	1.0	.....	1.2	25	1.5	0.8	0.2	1.2	79.1
6/7 /10	2	1,655	11.8	2.1	2.3	2.8	0.3	0.06	2.0	46	2.5	0.6	0.09	3.4	72.0
Av'r'ge	....	1,914	8.0	1.3	1.2	2.6	0.5	.....	1.2	28	1.7	0.5	0.1	1.3	81.5

TABLE NO. 134.

RESULTS OF MECHANICAL SEPARATION OF RUBBISH AND ASHES.

Dayton.

Date of Collection.	Number of Loads Included.	Average Weight of Load.	Constituents in Percentages.												
			Paper.	Rags.	Wood.	Tins.	Iron.	Other Metal.	Whole Bottles.		Glass and Broken Crockery.	Leather.	Garbage.		Ashes and Dirt.
									Weight.	Number.			Bones.	Other Garbage.	
5/19/09	1	5,375	0.8	0.6	0.9	2.0	0.1	.....	1.6	200	2.1	.....	0.1	.....	91.8
6/9 /09	1	4,590	3.5	0.8	3.3	6.8	0.3	.....	1.8	125	2.5	1.2	.....	.....	79.8
9/15/09	1	3,210	1.9	0.7	3.7	2.5	1.5	.....	0.9	.....	1.4	0.3	.....	.....	87.1
10/13/09	1	3,800	1.4	1.5	0.7	0.8	0.2	.....	0.4	30	1.3	0.7	0.2	1.2	91.6
11/12/09	1	3,885	1.9	0.1	1.9	1.8	0.8	.....	0.9	50	0.8	0.1	0.1	.....	91.6
12/10/09	1	3,730	2.9	0.1	2.9	1.3	1.3	.....	0.3	14	0.8	0.1	.....	.....	90.3
2/14/10	2	3,038	1.7	0.3	1.8	1.6	0.2	.....	0.4	23	0.6	0.1	.....	0.8	92.5
3/7 /10	3	5,340	0.7	0.6	0.9	2.0	0.1	0.8	0.5	44	0.8	0.1	.....	0.3	93.2
4/14/10	2	5,233	0.8	0.4	0.2	2.1	0.2	0.1	0.8	59	0.9	0.1	.....	.....	94.4
5/9 /10	2	4,360	0.3	0.2	0.6	2.6	0.1	.....	0.2	14	0.5	0.3	.....	.....	95.2
Av'r'ge	....	4,391	1.6	0.5	1.7	2.4	0.5	0.1	0.8	56	1.2	0.3	.....	0.2	90.8

TABLE NO. 135.

RESULTS OF MECHANICAL SEPARATION OF RUBBISH.

(Results of Table No. 132 Recalculated After Deducting Ashes and Dirt.)

Cleveland.

Date of Collection.	Number of Loads Included.	Constituents in Percentages.											
		Paper.	Rags.	Wood.	Tins.	Iron.	Other Metal.	Whole Bottles.		Glass and Broken Crockery.	Leather.	Garbage.	
								Weight.	Number.			Bones.	Other Garbage.
5/15/09	1	38.7	13.9	5.1	20.4	.....	0.7	.....	.....	18.8	2.9	.....	.....
7/21/09	1	44.7	8.7	6.8	21.8	.....	.....	5.6	25	10.6	.....	1.9	.....
9/17/09	1	16.7	7.1	8.3	9.5	11.9	.....	8.3	49	11.9	4.8	4.8	16.7
11/9 /09	2	16.0	5.5	21.0	25.0	4.0	1.0	9.0	72	15.5	3.0	.....	.....
1/20/10	1	29.6	8.2	38.8	9.2	1.0	.....	3.1	10	6.1	.....	2.0	2.0
3/11/10	1	41.8	3.2	6.5	12.0	.....	.....	2.5	29	28.7	0.4	.....	4.7
4/12/10	2	9.4	5.1	12.0	35.0	3.4	6.8	7.7	47	15.4	4.3	0.3	0.3
6/1 /10	1	34.4	9.1	10.1	16.2	8.6	0.5	9.6	70	7.1	3.0	.....	1.5
Averages	.....	28.9	7.6	13.6	18.6	3.6	1.1	5.7	38	14.2	2.3	1.1	3.2

TABLE NO. 136.

RESULTS OF MECHANICAL SEPARATION OF RUBBISH.

(Results of Table No. 133 Recalculated After Deducting Ashes and Dirt.)

Cincinnati.

Date of Collection.	Number of Loads Included.	Constituents in Percentages.											
								Whole Bottles.		Glass and		Garbage.	
		Paper.	Rags.	Wood.	Tins.	Iron.	Other Metal.	Weight.	Number.	Broken Crockery.	Leather.	Bones.	Other Garbage.
5/28/09	2	33.3	9.3	19.1	16.6	2.5	.....	4.3	15	8.0	0.6	2.5	3.7
6/11/09	1	58.5	6.9	3.1	9.6	3.5	.....	5.0	56	7.7	2.3	.....	3.5
6/12/09	2	49.7	9.8	2.4	9.1	6.6	.....	3.1	17	9.4	3.1	.....	7.0
7/9/09	1	52.2	4.8	7.6	18.1	.....	.....	3.6	13	6.0	7.6	.....	.....
9/10/09	1	33.3	8.2	6.4	9.1	1.4	.....	2.7	12	7.8	1.8	.....	29.2
10/6/09	1	33.3	7.0	11.5	11.5	1.9	.....	9.0	24	21.2	1.9	0.6	1.9
11/4/09	1	51.2	3.6	5.1	11.3	2.6	.....	9.7	61	12.3	1.0	0.5	2.6
12/7/09	1	26.4	3.2	5.3	20.0	4.2	.....	7.4	20	17.9	1.1	.....	14.7
2/10/10	4	34.9	6.1	4.1	30.3	0.6	.....	6.1	10	10.0	2.0	0.6	4.1
3/4/10	4	29.5	6.4	14.1	21.7	0.5	.....	7.7	17	11.5	1.3	1.3	6.4
4/8/10	2	35.3	4.1	2.9	26.5	1.8	0.1	11.2	49	15.3	2.4	.....	0.4
5/4/10	2	44.5	10.5	3.8	12.9	4.8	.....	5.7	25	7.2	3.8	1.0	5.7
6/7/10	2	42.2	7.5	8.2	10.0	1.0	0.2	7.1	46	8.9	2.0	0.3	12.1
Averages	.....	40.3	6.7	7.2	15.9	2.4	.....	6.4	28	11.0	2.4	0.5	7.0

TABLE NO. 137.

RESULTS OF MECHANICAL SEPARATION OF RUBBISH.

(Results of Table No. 134 Recalculated After Deducting Ashes and Dirt.)

Dayton.

Date of Collection.	Number of Loads Included.	Constituents in Percentages.											
								Whole Bottles.		Glass and		Garbage.	
		Paper.	Rags.	Wood.	Tins.	Iron.	Other Metal.	Weight.	Number.	Broken Crockery.	Leather.	Bones.	Other Garbage.
5/19/09	1	9.8	7.3	11.0	24.4	1.2	.....	19.5	200	25.6	.....	1.2	.....
6/9/09	1	17.3	4.0	16.3	33.7	1.4	.....	8.9	125	12.4	5.9	.....	.....
9/15/09	1	11.8	4.9	28.7	19.4	11.7	.....	7.0	.....	10.9	2.3	.....	.....
10/13/09	1	16.7	17.9	8.3	9.5	2.4	.....	4.8	39	15.5	8.3	2.4	14.3
11/12/09	1	22.6	1.2	22.6	21.4	10.7	.....	10.7	59	9.5	1.2	.4	.....
12/10/09	1	29.7	1.3	29.7	13.4	13.4	.....	3.2	14	8.2	1.3	.....	.....
2/14/10	2	22.7	4.1	24.0	21.4	2.7	.....	5.3	23	8.1	1.0	.....	10.7
3/7/10	3	10.3	8.8	13.2	29.4	.6	11.8	7.4	44	11.8	1.9	.3	4.4
4/14/10	2	14.2	7.4	3.3	37.0	4.4	.9	14.0	59	15.8	1.8	.4	.....
5/9/10	2	6.2	4.2	12.5	54.1	2.1	.....	4.1	14	10.8	6.2	.....	.....
Averages	.....	16.4	6.1	17.0	26.4	5.1	1.3	8.5	56	12.8	3.0	0.5	2.9

TABLE NO. 138.

RESULTS OF ANALYSES OF ASHES.

Cleveland.

Date of Collection.	No. of Loads Included.	Percentages.						Calorific Value B. T. U.	Sample Number.
		Unburned Coal.	Clinker and Cinders.	Fine Material.	Moisture.	Combustible.	Non-combustible.		
5/15/09	10	.....	.....	.....	26.0	23.95	50.05	2,175	26
11/9/9	27	.....	.....	.....	11.32	21.61	67.07	1,559	112
1/20/10	12	19.2	13.8	67.0	24.04	14.89	61.07	1,150	162
3/11/10	13	11.2	22.8	66.00	15.5	21.89	62.61	2,046	197
4/12/10	32	23.51	14.73	61.76	7.90	27.88	64.22	2,436	204
6/1/10	15	24.2	11.0	64.8	*.....	21.85	78.15	1,527	228
Averages	.....	19.5	15.6	64.9	14.1	22.0	63.9	1,815	.....

NOTES.

26 Sample from 79th St. Dump.
112 Sample from Salt Works Dump (55th St.)
162 Sample from Erie St. Dump.
197 Sample from Case Ave. Dump.
204 Sample from 79th St. Dump.
228 Sample from W. 53rd St. Dump.
* Moisture not determined. Results for other determinations on this sample are given on dry basis.

TABLE NO. 139.

RESULTS OF ANALYSES OF ASHES.

Cincinnati.

Date of Collection.	No. of Loads Included.	Percentages.						Calorific Value B. T. U.	Sample Number.
		Unburned Coal.	Clinker and Cinders.	Fine Material.	Moisture.	Combustible.	Non-combustible.		
10/6/09	1	15.3	1.7	83.0	.....	35.42	64.58	3,106	102
12/7/09	34	33.3	3.4	63.3	11.2	29.30	59.50	2,726	133
2/10/10	14	19.30	8.77	71.93	6.4	19.00	74.60	1,464	*173
3/4/10	67	32.2	3.9	63.9	17.6	24.36	58.04	2,694	189
4/8/10	4	18.9	14.0	67.1	2.66	38.41	58.93	4,579	202
5/4/10	52	22.90	9.05	68.05	9.74	29.96	60.30	2,896	219
6/7/10	45	28.9	5.4	65.7	7.0	37.25	55.75	4,145	234
Averages	.....	24.4	6.6	69.0	7.8	30.5	61.7	3,087	.....

NOTES.

102 Sample taken from Load Separated, 2d St. Loading Sta.
133 Sample from Liberty St. Dump.
173 Sample from Cincinnati Northern Dump.
189 Sample from 8th St. Dump.
202 Sample from Clarion St. Dump.
219 Sample from Liberty St. Dump.
234 Sample from 8th St. Dump.
* Average of two samples.

TABLE NO. 140.

RESULTS OF ANALYSES OF ASHES.

Dayton.

Date of Collection.	No. of Loads Included.	Percentages.						Calorific Value B. T. U.	Sample Number.
		Unburned Coal.	Clinker and Cinders.	Fine Material.	Moisture.	Combustible.	Non-combustible.		
4/10/09	11	19.0	19.0	62.0	15.26	24.45	60.29	2,199	12
5/19/09	1	.....	.....	.....	24.75	20.05	55.20	758	35
11/12/09	6	.....	.....	.....	15.40	20.12	64.48	1,448	116
12/10/09	5	8.8	15.8	75.4	8.40	27.47	64.13	3,221	138
2/14/10	15	17.4	16.3	66.3	21.80	12.06	66.64	1,199	*178
3/7 /10	9	24.7	11.8	63.5	26.00	17.80	56.20	1,742	194
4/14/10	24	15.7	9.8	74.5	9.96	23.99	66.05	1,584	205
5/9 /10	64	21.1	10.7	68.2	21.70	23.27	55.03	1,406	221
6/9 /10	3	41.3	5.4	53.3	30.90	24.21	44.89	2,094	236
Averages	.....	21.1	12.7	66.2	19.80	21.49	59.21	2,517	.....

NOTES.

35 Sample from Analyzed Load at Orth Dump.
116 Sample from Spice Mills Dump.
138 Sample from Orth Dump.
178 Sample from Longworth Dump.
194 Sample from Orth Dump.
205 Sample from Longworth Dump.
221 Sample from Herman St. Dump.
236 Sample from Orth Dump.
* Averages of two samples.

APPENDIX VI.

MISCELLANEOUS ANALYSES.

ANALYSES OF STREET CLEANINGS.

ANALYSES OF COAL.

ANALYSES OF ASHES FROM CREMATORIES

TABLE NO. 141.

RESULTS OF ANALYSES OF STREET CLEANINGS.

Sample Number.	City.	Date of Collection.	No. of Loads Included.	Percentages.			Calorific Value B. T. U.	Percentages.			
				Moisture.	Ash.	Combustible Matter.		Ether Extract.	Phosphoric Acid as P_2O_5.	Nitrogen Kjeldahl Method.	Potash as K_2O.
39	Cincinnati	5/28/09	9	52.4	35.41	12.19	1,231	....	0.12	0.20	0.10
50	Cincinnati	6/12/09	5	45.1	40.43	14.47	1,378	....	0.17	0.23	0.05
61	Cincinnati	7/9/09	13	50.2	35.05	14.75	1,417	....	0.16	0.20	0.08
196	Cleveland	3/11/10	17	29.2	50.01	20.79	1,874	....	0.20	0.26	0.09
199	Cincinnati	4/6/10	4	43.3	45.59	11.11	1,344	....	0.13	0.17	0.08
206	Dayton	4/14/10	4	.....	82.13	17.87	1,661	....	0.22	0.24	0.43
218	Cincinnati	5/4/10	8	24.5	61.36	14.14	1,634	....	0.12	0.26	0.10
225	Cleveland	5/13/10	1	28.9	47.57	23.53	2,301	....	0.16	0.34	0.18
233	Cincinnati	6/7/10	20	47.7	35.60	16.70	1,657	....	0.18	0.31	0.26

NOTES.

Sample 39 was taken at the Second Street Loading Station.
Sample 50 was taken at the Cincinnati Southern Dump.
Sample 61 was taken at the Gest Street Dump.
Sample 196 was taken at the Case Avenue Dump.
Sample 199 was taken at the Gest Street Dump.
Sample 206 was taken at the Longworth Dump. Sample was very dry and dusty.
Sample 218 was taken at the Liberty Street Dump.
Sample 225 was taken at Seymore Avenue Dump. Load covered a large area of streets, being composed of street cleanings from white wings' cans entirely.
Sample 233 was taken from white wings' cans at 8th Street Dump.

TABLE NO. 142.

RESULTS OF ANALYSES OF COAL.

Sample Number.	City.	Description of Sample.	Percentages.			
			Moisture.	Combustible Matter.	Non-combustible Matter.	Calorific Value B. T. U.
79	Canton	Coal used July 29 and 30, 1909	7.2	82.14	10.70	10,983
168	Canton	Coal used February 2 and 3, 1910	7.9	84.18	7.92	11,748
123	Mansfield	Coal used November 18 and 19, 1909	.....	95.58	4.42	12,617
97	Steubenville	Coal used September 23 and 24, 1909	.....	89.93	10.07	11,256
89	Zanesville	Coal used August 26 and 27, 1909	6.2	83.13	10.63	12,626
211	Zanesville	Coal used April 22, 1910	5.6	81.74	12.70	11,375

TABLE NO. 143.

RESULTS OF ANALYSES OF ASHES FROM CREMATORIES.

Sample Number.	City.	Description of Sample.	Percentages.			Calorific Value B. T. U.
			Moisture.	Combustible Matter.	Non-combustible Matter.	
76	Canton	Ash from garbage burned July 29, 1909	1.50	18.31	80.19	341
77	Canton	Ash from garbage burned July 30, 1909	0.25	13.49	86.51	.....
166	Canton	Ash from garbage burned February 2 and 3, 1910	.....	8.07	91.93	.....
119	Mansfield	Ash from garbage burned November 18, 1909	.....	16.61	83.39	903
121	Mansfield	Ash from garbage burned November 19, 1909	7.60	16.95	75.45	1,370
108	Marion	Ash from garbage burned October 28 and 29, 1909	.....	12.24	87.76	468
109	Marion	Ash from night soil burned October 28 and 29, 1909	.....	1.22	98.78	.....
98	Steubenville	Ash from garbage burned September 23, 1909	.....	12.45	87.55	.....
96	Steubenville	Mixed ashes from garbage and coal burned September 23, 1909	.....	14.85	85.15	569
99	Steubenville	Mixed ashes from garbage and coal burned September 24, 1909	.....	16.97	83.03	1,292
87	Zanesville	Mixed ashes from garbage and fuel burned August 26, 1909	8.8	28.94	62.26	2,197
88	Zanesville	Mixed ashes from garbage and fuel burned August 27, 1909	19.4	23.16	57.48	1,746
208	Zanesville	Ash from garbage burned April 22, 1910 (fine)	4.3	18.76	76.94	1,661
209	Zanesville	Ash from garbage burned April 22, 1910 (coarse)	.....	15.73	84.27	1,502
78	Canton	Ash from coal burned July 29, 1909	9.9	16.79	73.31	1,903
167	Canton	Ash from coal burned February 2 and 3, 1909	.....	20.64	79.36	1,924
120	Mansfield	Ash from coal burned November 18, 1909	.....	19.21	80.79	1,773
122	Mansfield	Ash from coal burned November 19, 1909	.....	13.22	86.78	879
210	Zanesville	Ash from coal burned in stench consumer April 22, 1910.	.....	27.19	72.81	3,102

APPENDIX VII.

WEIGHT OF GARBAGE—WEIGHT OF RUBBISH AND ASHES.

CLEVELAND.

CINCINNATI.

COLUMBUS.

DAYTON.

TABLE NO. 144.

WEIGHT OF GARBAGE.

Cleveland.

Month, 1909.	*Weight of Garbage (tons).	*Volume of Garbage (cu. yds.).	Weight per Cubic Yard (pounds).
January	3,511	5,370	1,310
February	2,988	4,510	1,325
March	3,200	4,779	1,340
April	2,961	4,510	1,315
May	3,186	4,726	1,350
June	3,966	5,420	1,460
July	3,955	5,745	1,375
August	4,512	6,713	1,315
September	4,803	6,713	1,435
October	4,348	6,014	1,445
November	4,037	5,585	1,445
December	3,233	5,800	1,115
Totals	44,600	65,885	1,354

* Department Records.

TABLE NO. 145.

WEIGHT OF GARBAGE.

Cincinnati.

Month. 1909.	*Weight of Garbage (tons).	*Volume of Garbage (cu. yds.).	Weight per Cubic Yard (pounds).
January	1,844.1	3,013	1,225
February	1,808.2	2,913	1,240
March	1,769.0	2,890	1,225
April	2,403.1	3,808	1,260
May	2,372.2	3,748	1,265
June	3,158.6	4,817	1,310
July	4,314.4	6,441	1,340
August	4,215.6	5,964	1,415
September	4,791.8	7,019	1,365
October	2,852.7	4,658	1,225
November	2,622.4	4,198	1,245
December	2,609.6	4,450	1,175
Totals	34,761.7	53,919	1,289

* Department Records.

TABLE NO. 146.

WEIGHT OF GARBAGE.

Columbus.

Date.	No. of Loads Weighed.	Weight per Cubic Yard (pounds).
May 17, 1909	17	1,177
June 1 to 5, 1909	149	1,315
July 6, 1909	31	1,323
August 6, 1909	35	1,208
September 7, 1909	30	1,221
October 4, 1909	30	1,239
November 1, 1909	25	1,299
November 29 to December 4, 1909	261	1,253
January 4, 1910	41	1,022*
January 31, 1910	23	1,077*
February 25, 1910	32	819*
April 4, 1910	33	1,229
May 6, 1910	37	1,160
May 28, 1910	26	1,222
Average	.....	1,180

* Garbage frozen.

TABLE NO. 147.

WEIGHT OF GARBAGE.

Dayton.

Date.	No. of Loads Weighed.	Weight per Cubic Yard (pounds).
April 9 and 14, 1909	25	1,510
May 20, 1909	15	1,639
June 7, 1909	11	1,512
July 12 to 17, 1909	102	1,550
September 13, 1909	12	1,596
October 11 and 20, 1909	36	1,612
November 10, 1909	20	1,538
December 8, 1909	18	1,295
January 10 to 14, 1910	81	1,164*
February 14, 1910	17	1,350
March 7, 1910	18	1,523
April 25, 1910	19	1,538
May 9, 1909	22	1,551
June 9, 1909	20	1,490
Average	.....	1,490

* Garbage frozen.

TABLE NO. 148.

WEIGHT OF RUBBISH AND ASHES.

Cleveland.

Date.	Number of Loads Weighed.	Average Weight of Load.	Average Volume of Load Cu. Yds.	Average Weight per Cu. Yd.	Average Percentage Ashes and Dirt.
May 15, 1909	5	3,498	3.5	999	86.2
July 21, 1909	1	3,090	3.5	883	83.7
September 17, 1909	1	3,750	3.5	1,071	90.2
November 11, 1909	2	2,363	3.5	675	71.9
January 20, 1910	2	3,041	3.5	869	90.1
March 11, 1910	1	2,540	3.5	726	70.0
April 12, 1910	5	2,858	3.5	817	86.8
June 1, 1910	1	2,220	3.5	634	80.2
Average		2,920	3.5	834	82.4

TABLE NO. 149.

WEIGHT OF RUBBISH AND ASHES.

Cincinnati.

Date.	Number of Loads Weighed.	Average Weight of Load.	Average Volume of Load Cu. Yds.	Average Weight per Cu. Yd.	Average Percentage Ashes and Dirt.
May 28, 1909	2	1,680	2.46	682	83.7
June 11, 1909	4	1,883	2.46	765	72.4
July 9, 1909	1	1,300	2.37	549	73.2
September 10, 1909	1	1,818	2.37	767	78.0
October 6, 1909	1	2,000	2.55	784	84.5
November 4, 1909	1	2,000	2.55	784	80.5
December 7, 1909	1	2,080	2.37	878	90.4
February 10, 1910	5	2,139	2.41	888	93.2
March 4, 1910	4	2,390	2.37	1,009	92.1
April 6, 1910	7	1,697	2.45	693	82.3
May 4, 1910	4	1,463	2.37	617	76.6
June 7, 1910	5	1,650	2.41	685	72.1
Average		1,842	2.43	759	81.6

TABLE NO. 150.

WEIGHT OF RUBBISH AND ASHES.

Dayton.

Date.	Number of Loads Weighed.	Average Weight of Load.	Average Volume of Load Cu. Yds.	Average Weight per Cu. Yd.	Average Percentage Ashes and Dirt.
May 19, 1909	1	5,375	3.52	1,529	91.7
June 9, 1909	1	4,590	4.29	1,070	78.3
September 15, 1909	1	3,210	3.52	913	85.8
October 13, 1909	1	3,800	3.78	1,005	86.1
November 12, 1909	1	3,885	4.52	859	82.0
December 10, 1909	1	3,730	3.52	1,059	90.2
February 14, 1910	2	3,038	4.52	672	91.7
March 7, 1910	3	5,340	3.86	1,383	92.7
April 14, 1910	2	5,233	4.30	1,217	93.4
May 9, 1910	2	4,860	4.52	1,075	94.6
Average	.....	4,458	4.09	1,090	90.1

LIST OF PLATES.

PLATE I. Canton Garbage Crematory.

PLATE II. Mansfield Garbage Crematory.

PLATE III. Marion Garbage Crematory.

PLATE IV. } Steubenville Garbage Crematory.
PLATE V. }

PLATE VI. }
PLATE VII. } Zanesville Garbage Crematory
PLATE VIII. }

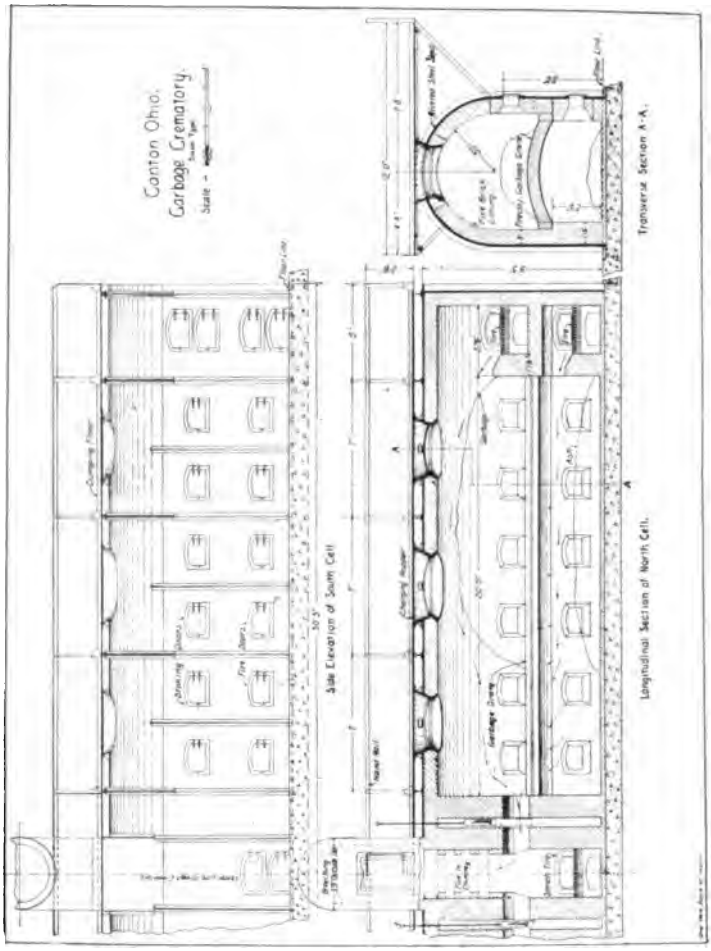

Canton Ohio.
Garbage Crematory.
Scale - 1/4" = 1'-0"
Side Elevation of South Cell
Longitudinal Section of North Cell.
Transverse Section A-A.

PLATE I.

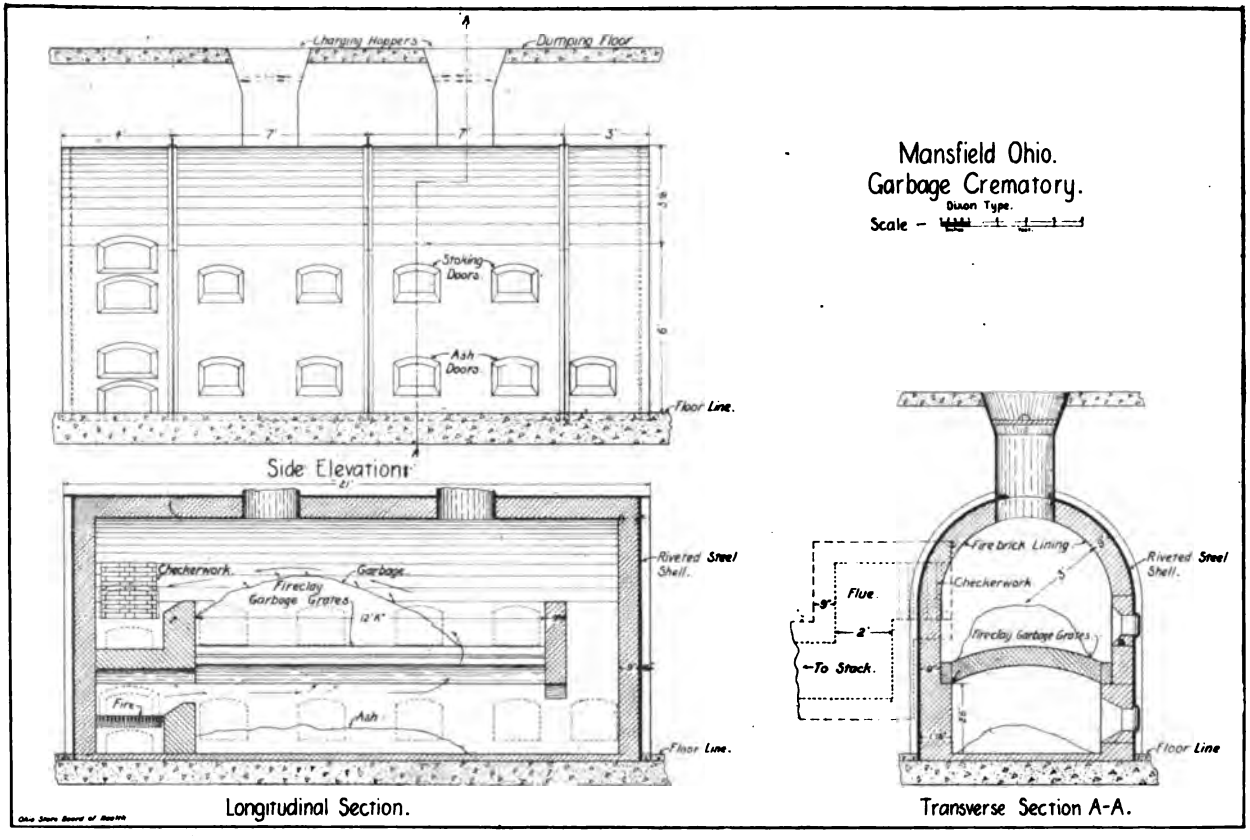
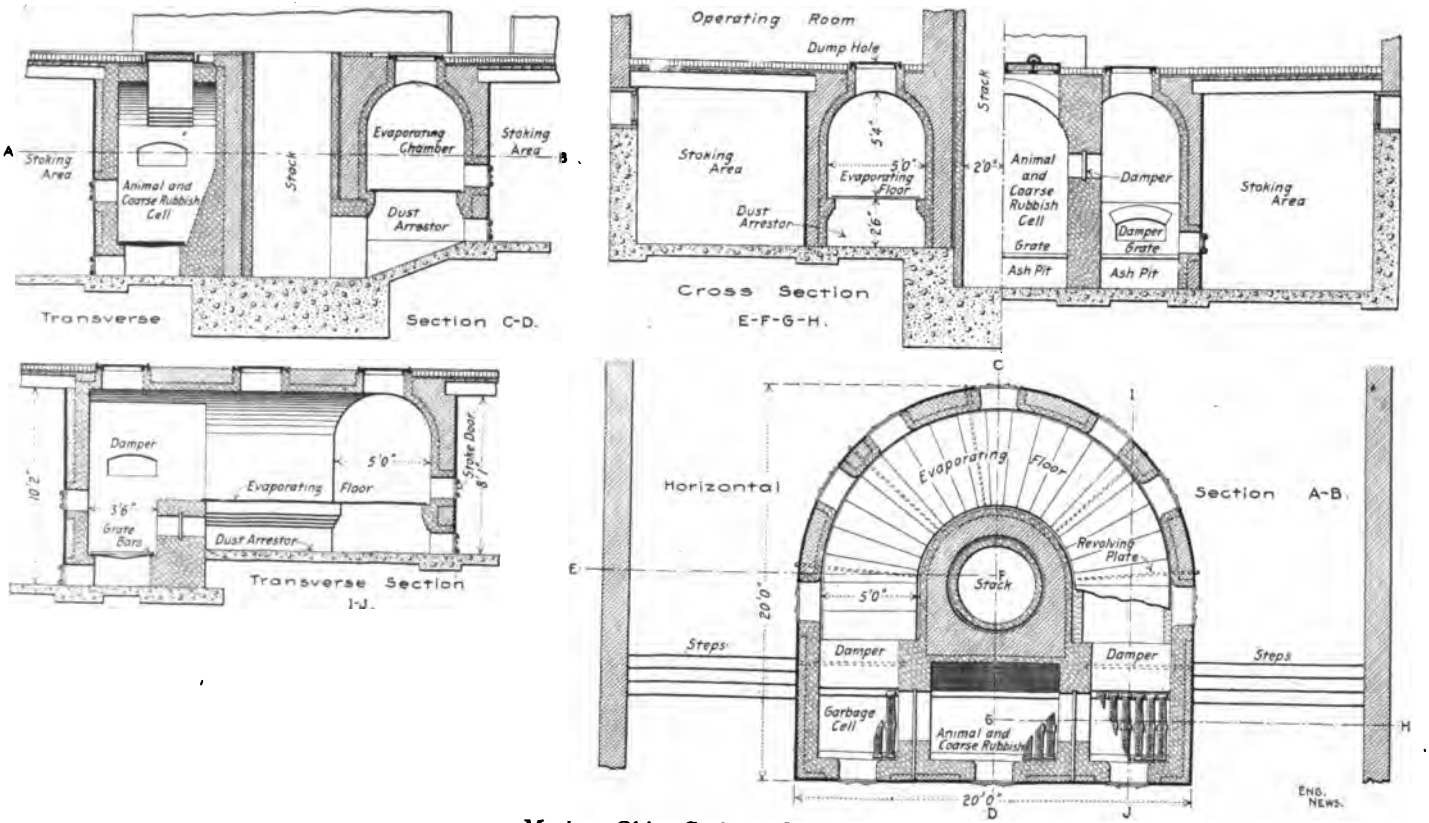

Charging Hoppers
Dumping Floor
7'
7'
3'
Stoking Doors
Ash Doors
Floor Line.
Side Elevations
21'
Riveted Steel Shell.
Checkerwork.
Garbage
Fireclay Garbage Grates
12'6"
Fire
Ash
Floor Line.
Longitudinal Section.
Mansfield Ohio.
Garbage Crematory.
Dixon Type.
Scale –
Fire brick Lining
Riveted Steel Shell.
Checkerwork
Flue.
9'
2'
To Stack.
Fireclay Garbage Grates
Floor Line
Transverse Section A-A.

PLATE II.



Marion, Ohio, Garbage Crematory.

PLATE III.

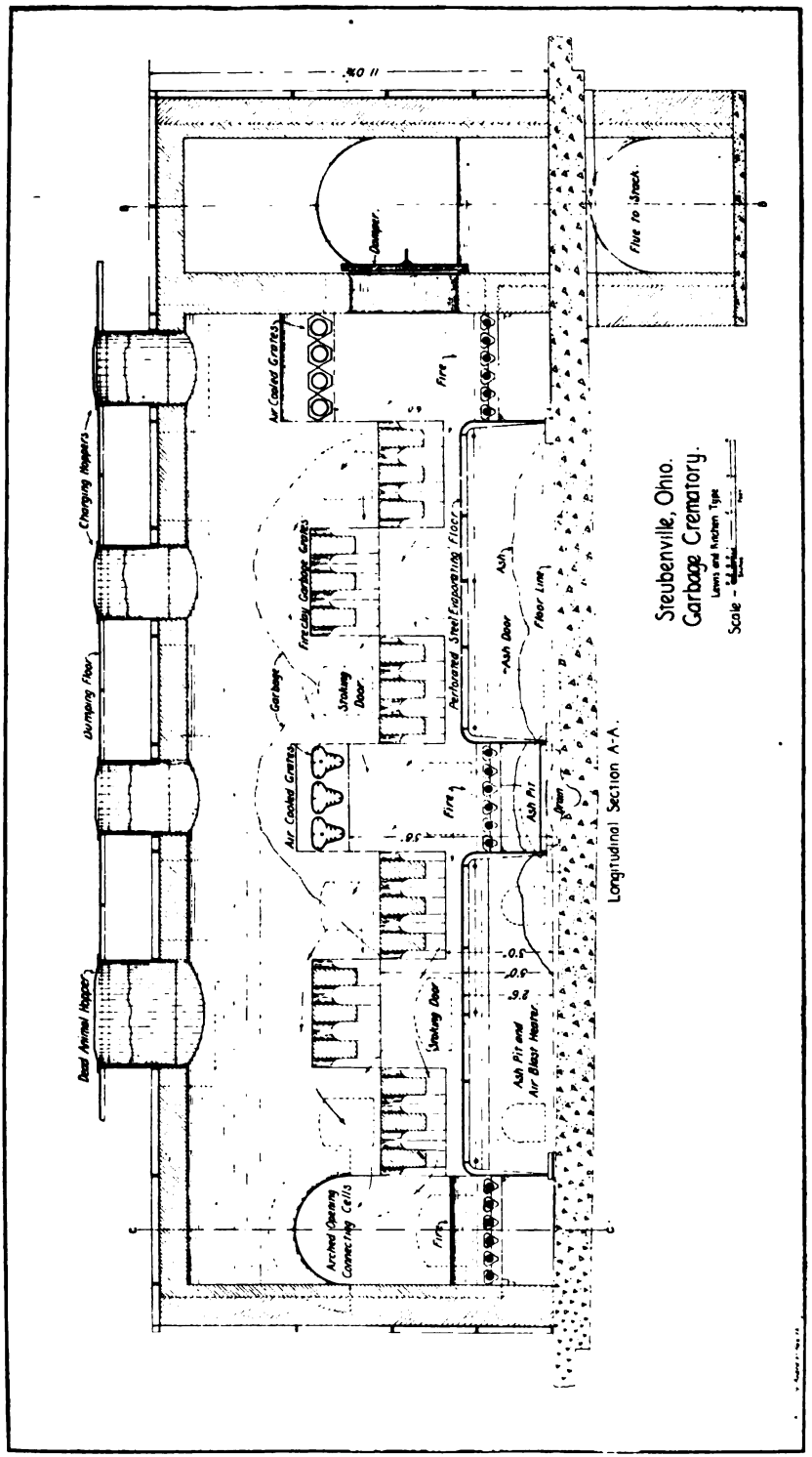

Steubenville, Ohio.
Garbage Crematory.
Longitudinal Section A-A.
Charging Hoppers
Dumping Floor
Dead Animal Hopper
Air Cooled Grates
Garbage
Smoking Door
Fire
Ash Pit
Ash Pit and Air Blast Heater
Arched Opening Connecting Cells
Perforated Steel Evaporating Floor
Ash Door
Floor Line
Damper
Flue to Stack

PLATE IV.

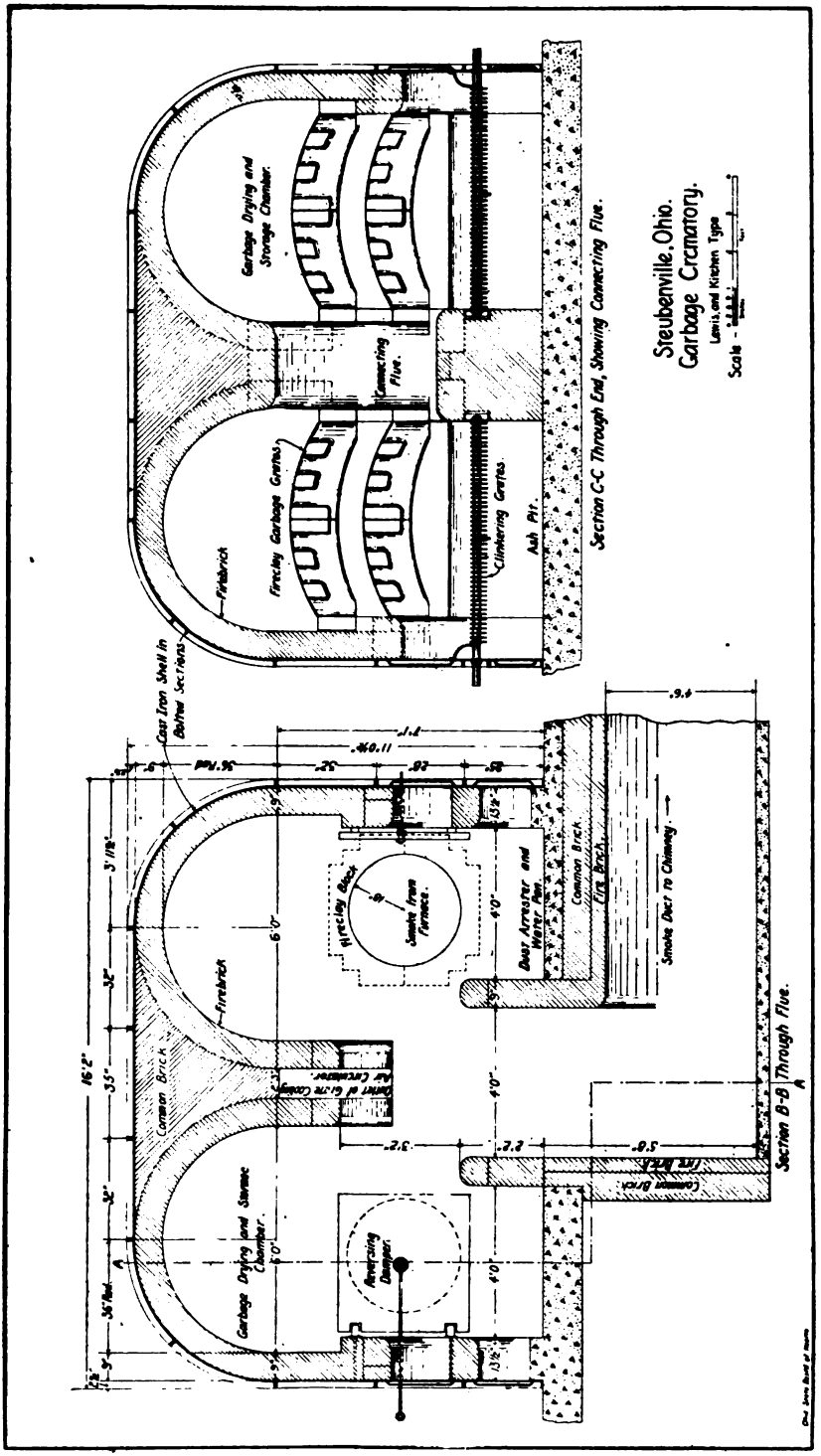

Steubenville, Ohio.
Garbage Crematory.
Lewis and Kitchen Type
Scale - 1/4" = 1'
Section C-C Through End, Showing Connecting Flue.
Garbage Drying and Storage Chamber.
Connecting Flue.
Firebrick
Firebrick Garbage Grates.
Clinkering Grates.
Ash Pit.
Cast Iron Shell in Bolted Sections
Section B-B Through Flue.
Garbage Drying and Storage Chamber.
Reversing Damper
Common Brick
Fire Brick
Firebrick
Firebrick Bridge
Smoke from Furnace.
Dust Arrester and Water Pan.
Smoke Door to Chimney.
Common Brick
Fire Brick
Ash Pit

PLATE V.

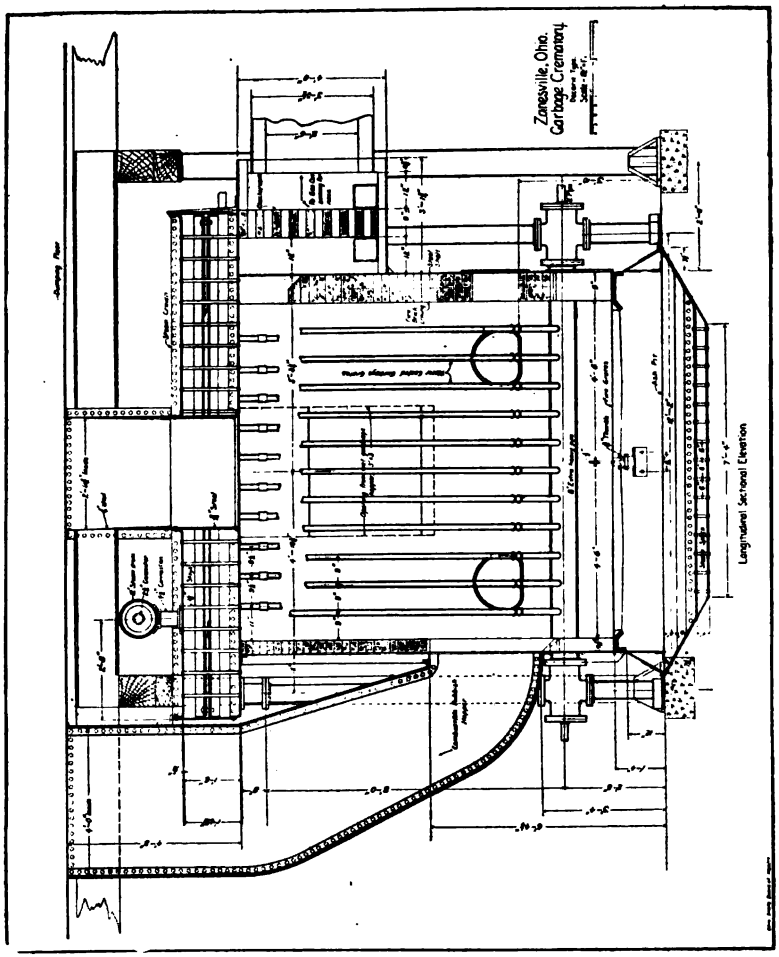

Zanesville, Ohio.
Garbage Crematory.
Longitudinal Sectional Elevation

PLATE VI.

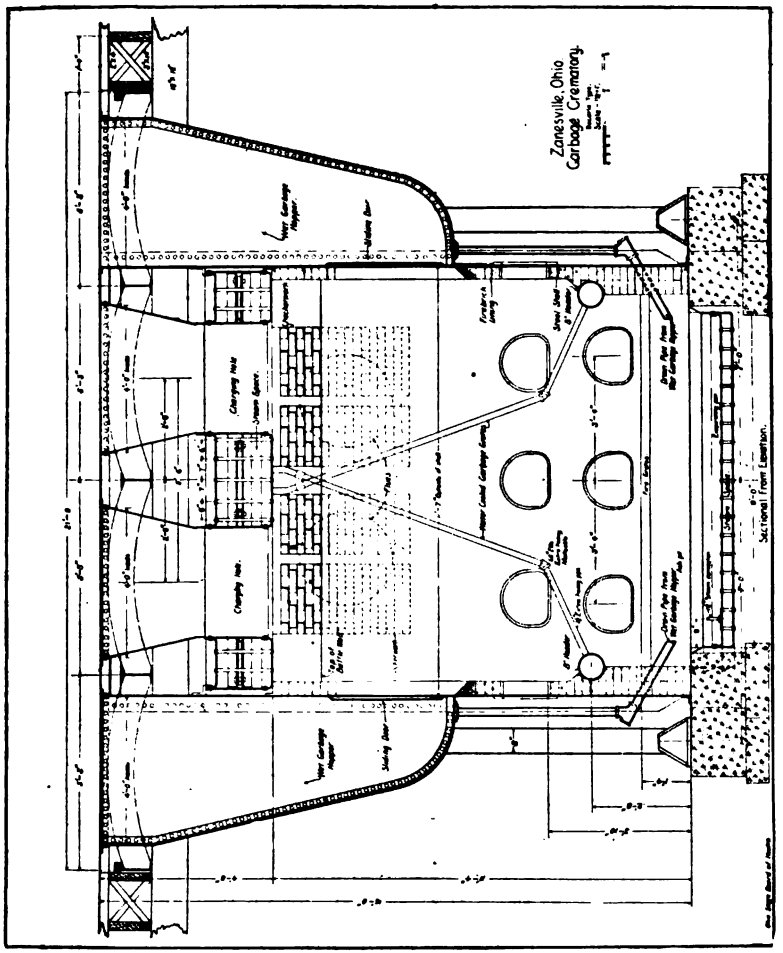
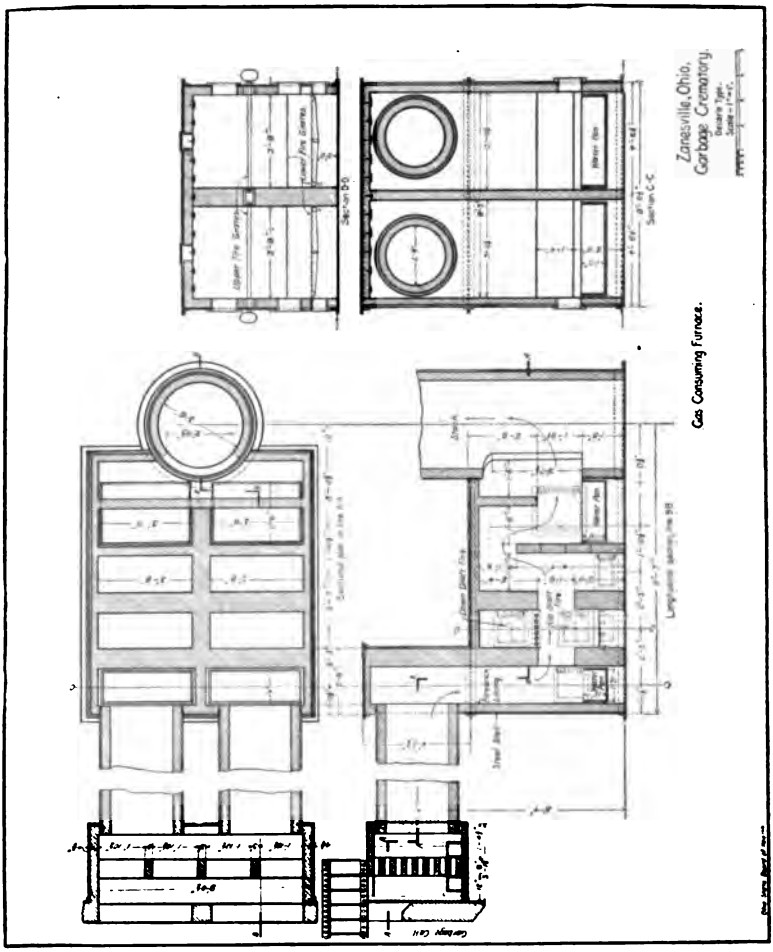


PLATE VII.



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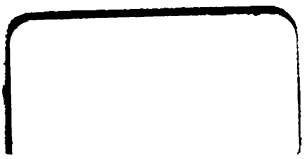

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